Virginia Department of
Environmental Quality

Guest River

Total Maximum Daily Load Report

TMDL Study for Aquatic Life Use Impairment

September 2003

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EXECUTIVE SUMMARY

In 1998, the Virginia Department of Environmental Quality (VADEQ) listed Guest River mainstem, from its headwaters to confluence with Bad Branch, as impaired for violations of the general water quality standard, i.e. for failure to support the aquatic life use. Section 303(d) of the Clean Water Act and Environmental Protection Agency (EPA) Water Quality Planning and Management Regulations (40 CFR Part 130) require states to develop Total Maximum Daily Loads for waterbodies which do not meet water quality standards.

The Guest River impairment was identified through benthic macroinvertebrates surveys. Biological monitoring indicated that aquatic life uses were impaired. This is a violation of the general water quality criteria. This standard, (9 VAC 25-260-20 A), states that "*All state waters, including wetlands, shall be free from substances attributable to sewage, industrial waste, or other waste in concentrations, amounts, or combinations which contravene established standards or interfere directly or indirectly with designated uses of such water or which are inimical or harmful to human, animal, plant, or aquatic life.*"

In 2001, VADEQ contracted with Tennessee Valley Authority (TVA) to develop a sediment and nutrient loading estimate model for the Guest River. As part of the contract, TVA took infrared aerial photographs of the watershed and transferred the photo-interpretations of land use and land cover to digital format. The land use and land cover data were combined with a pollutant loading model to estimate sediment loadings in terms of tons per acre per year. The underlying equations for the model, the Integrated Pollutant Source Identification (IPSI) tools, are the Universal Soil Loss Equation and the EPA equation for Urban land uses based on a 1990 report, *Urban Targeting and BMP Selection*. Results of the water quality data indicated that total suspended solids were the parameter of interest.

The TVA's IPSI tools allowed predicted estimates of yearly total suspended loads based on reductions in soil losses. The target loading endpoint chosen mimics the loading in non-impacted sub-watersheds within the basin. The argument is that if estimated loads of total suspended solids have no impact on the benthic macroinvertebrates in these sub-watersheds, then the same loading in the mainstem of Guest River should allow recovery of impacted populations.

Reduction of sediment loadings requires installation of best management practices in the watershed to reduce erosion from the contributing sources. The main sources of sediments are abandoned mine features, urban sources, pastures, and stream bank erosion. The following describes two phases of reduction strategies, which result in achieving the total suspended solids endpoint.

An interim load reduction scenario includes repair of all abandoned mine features, full cover on 50% of previously mined lands, 50% of overgrazed pasture improved to fair and 50% of fair pasture converted to good, 10% reduction of urban sources and 25% reduction of disturbed areas delivery to the streams, repair of 33% of eroding perennial stream banks and reduction of road bank erosion by 20%.

The final load reduction scenario includes repair of all abandoned mine features, 100% of all previously mined land improved, all overgrazed pasture improved to fair and all fair pasture improved to good, half of eroding stream banks repaired, 50% reduction of erosion from unpaved roads and road cuts, 50% runoff from urban sources, reduce delivery from clear-cuts by 25%, from disturbed areas by 70%, and scrub/shrub areas improved to 100% cover, and Sepulcher Creek tipple delivery reduced by 90%.   The TMDL is defined as follows:

Table ES-1. Guest River Sediment TMDL (tons/year)

TMDL	WLA	LA	MOS
9,635.63	317.52	9,318.11	implicit

Chapter

1

1.0 INTRODUCTION

Section 303(d) of the Clean Water Act and 40 CFR Part 130 require states to develop Total Maximum Daily Loads (TMDLs) for waterbodies which are exceeding water quality standards. TMDLs represent the total pollutant loading that a waterbody can receive without violating water quality standards. The TMDL process establishes the allowable loadings of pollutants for a stream based on the relationship between pollution sources and in-stream water quality conditions. By following the TMDL process, states can establish water quality based controls to reduce pollution from both point and nonpoint sources to restore and maintain the quality of their water resources (EPA, 1991).

1.1 Background

The Guest River watershed, designated VAS-P11R, comprises approximately 64,200 acres and 161.8 river miles. The entire length of Guest River and all of its tributaries are located within this watershed. Twenty-three percent of Wise County drains to Guest River. Fifty-two percent of the city of Norton drains to the Guest River watershed, whereas less than half a percent of Dickenson and Scott Counties drain to the watershed. Guest River is a tributary to Clinch River. The Guest River confluence with Clinch River is at river mile 244.1. Guest River is in the Tennessee River Basin, Hydrologic Unit Code 06010205. The communities of Flatwoods, Lipps, Tacoma, Banner, the Towns of Coeburn and Wise and part of the City of Norton are within the watershed.

In 1993, the VADEQ identified the benthic community in the Guest River as impaired . A segment of Guest River was subsequently listed for violations of the general standard on Virginia's 1996 303(d) list. In a separate listing, the main stem of the Guest River and several tributaries were also listed in 1996 as impaired for violations of the fecal coliform criteria protecting the swimming use. Since then, data from both the main stem of the Guest River as well as two tributaries (Yellow Creek and Bear Creek) showed attainment of the fecal coliform standard. In 2003, these stream sections were removed from the 303(d) list. Bacteria TMDL development for three tributaries to the Guest River is currently ongoing and is expected to be complete in early 2004.

In 1995, the Tennessee Valley Authority staff consulted with DEQ staff regarding impaired watersheds for developing projects to improve water quality and aquatic health. Since the water was identified as impaired and then targeted by TVA River Action Team efforts, many activities have taken place to correct water quality problems. These efforts have ranged from water quality data collection to community education to facilitating on the ground best management practices.

Figure 1.1 is a location map for the Guest River watershed. This figure depicts its location within the county as well as its location relative to the state.

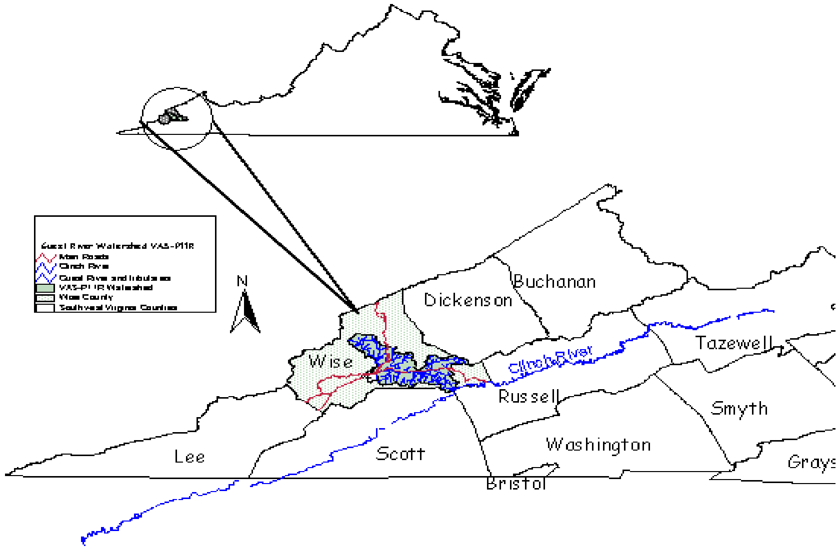


Figure 1.1 Guest River Watershed Location

1.2 Impairment Listing

Table 1.1 Guest River Impairment Information

Segment ID	County	Station ID	Year Initially Listed	Impairment		
				Cause	Source	Length
6BGUE04A96	Wise	6BGUE006.50	1996	General Standard (Benthic)	Resource Extraction	8.93
6BGUE03A98	Wise	6BGUE006.50	1998	General Standard (Benthic)	NPS-Urban, Resource Extraction	18.72

The Guest River impairment listing is based on evaluations of biological monitoring data that focus on the benthic (bottom-dwelling) macro (large enough to see with the naked eye) invertebrates (insects, mollusks, crustaceans, and annelid worms). Benthic macroinvertebrates are used to determine whether a stream segment is supporting the aquatic life use. Changes in water quality generally result in changes in the types and numbers of the benthic organisms that live in streams and other water bodies. Besides being the major intermediate constituent of the aquatic food chain, benthic macroinvertebrates are "living recorders" of past and present water quality conditions. This is due to their relative immobility and their variable resistance to the diverse contaminants that may be found in streams. The community structure of these organisms provides the basis for the biological analysis of water quality. VADEQ has conducted qualitative and semi-quantitative biological monitoring since the early 1970's. The USEPA Rapid Bioassessment Protocol II (RBP II) was employed beginning in the fall of 1990 to use standardized and repeatable methodology. For any single sample, the RBP II produces water quality ratings of “non-impaired,” “slightly impaired,” “moderately impaired,” and “severely impaired.” Generally, VADEQ biologists sample the benthic community twice a year, in the spring and in the fall.

In 1996, a 27.65-mile segment of Guest River, from its headwaters to the confluence with Bad Branch was listed as impaired. Table 2.1 above identifies the monitoring station used for listing this segment. The station is located in Coeburn at the Route 72 bridge. There is no one chemical parameter directly linked to benthic health. Aquatic biology is complex. Potentially, many stressors, that alone do not impair the benthic community, may have a cumulative deleterious impact on macroinvertebrates quantity and variety. For the Guest River, the VADEQ biologist concluded that loss of habitat due to sedimentation was the probable source of benthic impairment.

Since resource extraction is one of the most prevalent land uses in the watershed, it is the most likely source of sedimentation. Resource extraction includes a number of activities that can contribute to sediment loads entering the stream. Resource extraction activities include strip mining, coal processing, coal haul roads and coal tipples or coal loading facilities. Abandoned mine lands that have poor drainage and poor land cover are also present in the watershed and although coal mining activities have ceased, this land use category could contribute to soil loss through erosion. Other land uses in the watershed include forestry and urban centers with dense populations along the stream banks. Urban areas and logging activities can also contribute elevated sediment loads to a stream.

1.3 Applicable Water Quality Standard

The Virginia Water Quality Standards (9 VAC 25-260-5) define "water quality standards" as *provisions of state or federal law which consist of a designated use or uses for the waters of the Commonwealth and water quality criteria for such waters based upon such uses. Water quality standards are to protect the public health or welfare, enhance the quality of water and serve the purposes of the State Water Control Law (62.1-44.2 et seq. of the Code of Virginia) and the federal Clean Water Act (33 USC 1251 et seq.).*

In the Virginia Water Quality Standards (9 VAC 25-260-10 A) *All state waters are designated for the following uses: recreational uses e.g., swimming and boating; the propagation and growth of a balanced indigenous population of aquatic life including game fish, which might reasonably be expected to inhabit them; wildlife; and the production of edible and marketable natural resources, e.g., fish and shellfish.*

Further the general criteria, which is the basis of the aquatic life use impairment on Guest River, is defined in the Virginia Water Quality Standards (9 VAC 25-260-20 A). *All state waters, including wetlands, shall be free from substances attributable to sewage, industrial waste, or other waste in concentrations, amounts, or combinations which contravene established standards or interfere directly or indirectly with designated uses of such water or which are inimical or harmful to human, animal, plant, or aquatic life.*

Specific substances to be controlled include, but are not limited to: floating debris, oil, scum, and other floating materials; toxic substances (including those which bioaccumulate); substances that produce color, tastes, turbidity, odors, or settle to form sludge deposits; and substances which nourish undesirable or nuisance aquatic plant life.

Chapter
2

2.0 Watershed Characterization

2.1 Ecoregion and Physical Properties

An ecoregion is an informative natural division providing insight and perspective on stream quality. (EPA 2002). Ecoregions, which are areas that have similar soils, vegetation, climate, and physical geography, are identified for the entire US, including the Mid-Atlantic Highlands. The map, in Figure 2.1, shows "Level III" ecoregions. Finer details of these ecoregions result in "Level IV" ecoregions, which are not shown. The types of stream problems, and stressors creating these problems, become more apparent from the characteristics of the ecoregions.

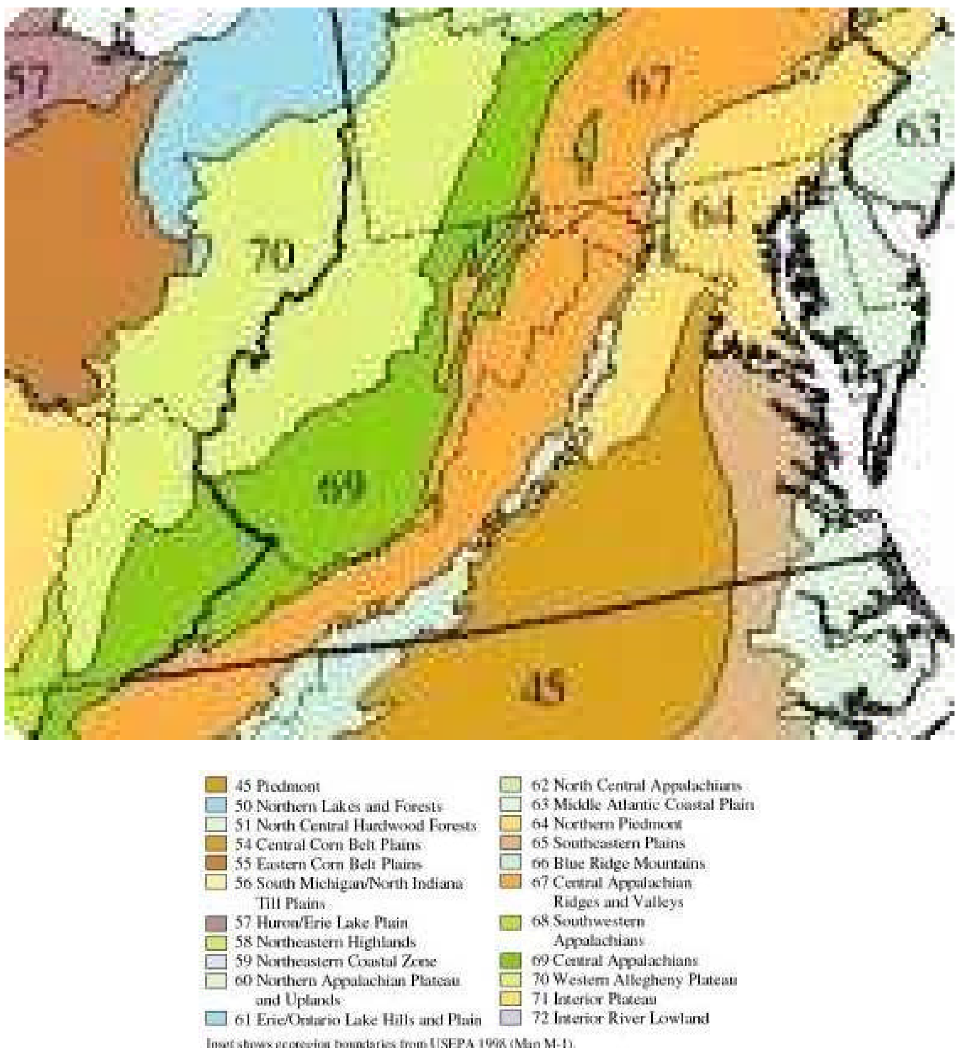


Figure 2.1. Ecoregion Level III Map

For example, mountains with their steep slopes, shallow soils, and cooler climate are very different from valleys that are relatively flat, have deep soils, and warmer temperatures. Mountain ridges might represent one ecoregion while valleys would represent a different ecoregion. Mountain streams are expected to naturally have a different quality than valley streams. An ecoregion perspective also helps us understand why streams respond to various human disturbances as they do and which management solutions might be applicable. The Guest River is located in the Central Appalachian ecoregion, stretching from central Pennsylvania to northern Tennessee. The Central Appalachian ecoregion is primarily a high, dissected, rugged plateau composed of sandstone, shale, conglomerate, and coal. The rugged terrain, cool climate, and infertile soils limit agriculture, resulting in a mostly forested land cover. The high hills and low mountains are covered by a mixed mesophytic forest with areas of Appalachian oak and northern hardwood forest. Bituminous coal mines are common, and have caused the siltation and acidification of streams. The southern part of the ecoregion in West Virginia is primarily a forested plateau composed of sandstone and shale geology and coal deposits. Due to the rugged terrain, cool climate, and infertile soils, this area is more forested and contains much less agriculture than the Valley and Western Appalachian ecoregions. Coal mining is a major industry in this region and acid mine drainage and stream siltation associated with coal mining is common.

Guest River geology consists of sandstone, shale, clay and coal. It is in the Appalachian Plateau physiographic province. There are areas of high relief with steep-sided valleys drained by tributaries to Guest River. The average elevation is between 2000 and 2500 feet. The streams generally have a steep gradient ranging from 10 percent slopes to 40 percent slopes. Areas which have been strip mined have slopes up to 55 percent. Soils within the watershed are sandy loam or clay due to the sandstone composition of the bedrock layers.

The Norton and Wise formations and Gladesville sandstone make up the geologic components of the region. These formations are in the Pennsylvanian Series of the Carboniferous system according to *U.S.G.S. Survey Bulletin No. XXIV*. Some of the sandstones and conglomerates are so resistant to weathering that they result in plateaus and outcrops of stone. These features are apparent in the Guest River Gorge towards the mouth of Guest River. Where slopes are very steep, removing trees and forest cover causes soils to erode quickly so that pasture or cultivation is not possible.

The geologic structure of the basin varies from horizontal formations to angled formations. That is, rather than a uniform horizontal thickness to each layer of either sandstone, clay, coal and shale, these fold and the thickness of each varies. Given the properties of each rock layer, their deformities vary. The harder stone will buckle whereas the softer stones may thin. Due to these deformities in the geologic formations, the location of the coal layers varies from the land surface to deep underground.

Coal availability and extraction occurs in the upper Guest River watershed and along the Rocky Fork, Sepulcher Creek, Yellow Creek and Bear Creek sub-watersheds. Mines exist on Toms Creek and Little Toms Creek as well. In the first half of the twentieth century, Wise County produced coke from the coal, limestone and lumber resources in this drainage. As noted earlier, lumber removed from steep slopes causes the soil mantle to quickly wash away.

2.2. Land Use

Guest River watershed covers about 64,200 acres. The land uses within the watershed are not homogeneous. Each sub-watershed has a unique make up based on land ownership and such factors as available resources and topography. Generally, there are four categories of land use in the watershed. The four uses include forestry, resource extraction lands, urban activities and agriculture. 32 land use categories were identified and mapped using TVA's remote sensing data (IPSI, 2002). Table 2.1 demonstrates how the 32 categories were aggregated into 10 land use groups. Table 2.2 provides aggregated acreages for the 10 major categories within the Guest River watershed.

Table 2.1 Individual and aggregated land use categories based on TVA's IPSI model [1]

IPSI Land Use Category	TMDL Land Use Category	Area (acres) [2]
Residential	Urban Land	6,139.6
Commercial		1,256.5
Developed Open		201.4
Industrial		347.2
Transportation		4.5
Airport		157.1
Railroad Yards		50.1
Major Hwy		442.5
Powerline		319.7
Natural Gas Wells		84.4
Railroad Line		N/A
Low Residue Row Crop	Cropland	9.1
Medium Residue Row Crop		1.9
Fair Pasture	Pastureland	2,500.7
Heavily Overgrazed Pasture		713.6
Orchard		58.8
Scrub/Shrub		554.7
Forest	Forest land	38,897.3
Clearcut		1,328.1
Active Strip Mines	Active Strip Mine	1,665.0
Tipples	Tipple	229.6
Reclaimed Strip Mine	Previously Mined Land	96.9
Abandoned with Highwall		4,808.6
Slide area		30.0
Contour Reclaimed		3,311.6
Slide		15.0
Abandoned Strip Mine		30.2
Borrow		45.3
Valley Fill		40.2
Disturbed Areas	Disturbed Areas	30.5
Abandoned Mine Features	Abandoned Mine Features	N/A
Stream Banks	Stream Banks	N/A
Unpaved Roads	Unimproved Roads	N/A
Road banks		N/A
Haul Roads		N/A
Livestock Access Areas	Livestock Access	N/A
Wetland	Wetlands	447.7
Open Water	Open Water/Flooded	384.0
Flooded		35.7
TOTAL		**64,237.50**

[1] For category definitions, please refer to the TVA Report, Appendix D

[2] N/A in the area column indicates that the land use category is a linear feature with no acreage attached

Table 2.2. Land Use Categories and Acreages for the Guest River Watershed

Land Use Category	Acres
Urban Land	9,003.00
Cropland	11.00
Pastureland	3,827.80
Forest Land	40,225.40
Active Strip Mine	1,665.00
Tipples	229.60
Previously Mined Land	8,377.80
Disturbed Areas	30.50
Wetlands	447.70
Open Water/Flooded	419.70
Total	64,237.50

(Source: IPSI 2002)

Figure 2.2 shows the subwatersheds in the Guest River watershed that were used for the loading model. The land use distribution at the subwatershed level is discussed below.

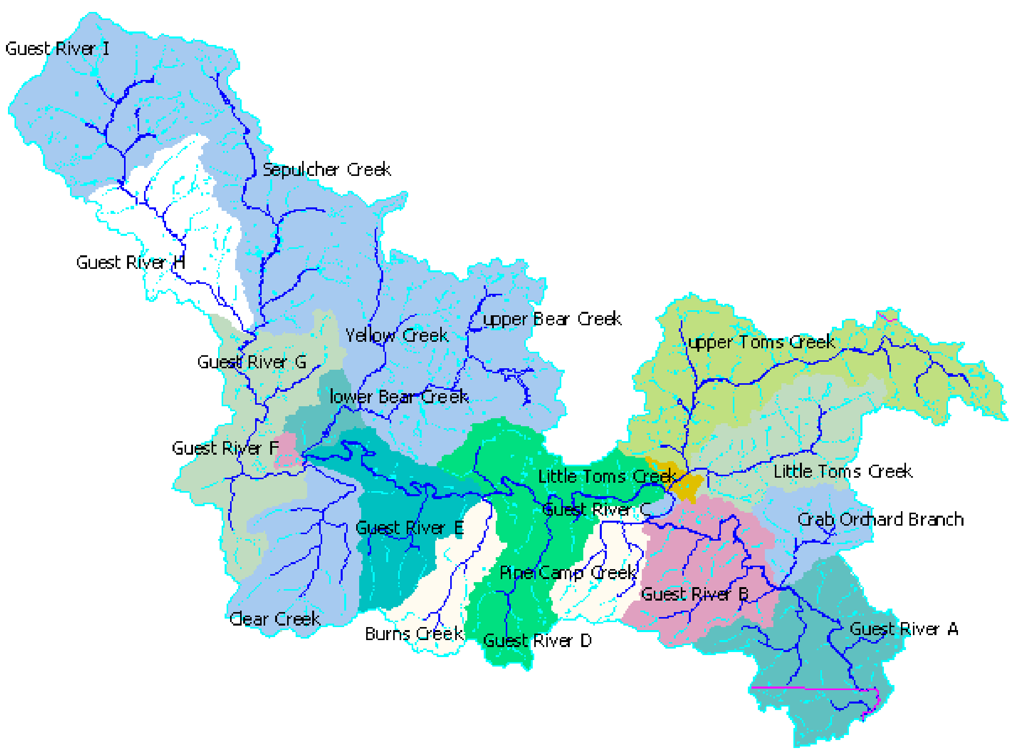


Figure 2.2 Guest River Sub-Watershed Locations

Forestry Land Use The Guest River watershed is approximately 63% forested. Each sub-watershed has a component of forested lands. A part of the George Washington Jefferson National Forest is in the Guest River watershed. Guest River F is the only sub-watershed with less than 30% forest cover. Clear Creek and Burns Creek have over 95% forest cover. Guest River A, Guest River B, Pine Camp Creek, and Guest River E have greater than 80% forest cover.

Resource Extraction Land Use Coal exports from Wise County began in 1892. Mined land today represents 16% of the watershed. Three primary categories of resource extraction land are identified and labeled by the TVA and listed in Table 2.2; Active Strip Mine, Tipples, and Previously Mined Land. Active Strip Mines include all lands currently covered under state issued Coal Surface Mining Reclamation Act (SCMRA) permits. Drainage from these lands is addressed in the TMDL's waste load allocation (WLA). Tipples include small coal loading facilities that are active but do not require a state SCMRA permit. Previously Mined Lands include all other lands previously disturbed by coal mining. Previously Mined Lands contain areas that have been properly reclaimed, such as older reclaimed contour surface mines, as well as, areas of abandoned mined land and abandoned mined land features. Drainage from the Tipples and Previously Mined Lands is addressed in the TMDL's load allocation (LA). The abandoned mined land features identified in table 2.1 describe specific attributes such as a segments of highwall, old mine portals, clogged streams, or spoiled outslopes. These attributes do not have associated acreage but are included within the acreage listed for previously mined lands. Sub-watersheds Guest River F and Guest River I have 50% to 60% mined lands. The Bear Creek sub-watersheds, Sepulcher Creek and Guest River H all have 20% to 25% mine lands.

Urban Land Use The next most prevalent land use is urban. Urban uses represent 13.9% of the watershed. Guest River C is 53% urban and lower Toms Creek is 64%. Urban land use is characterized by highly impervious surfaces.

Agricultural Land Use Agriculture is a minor activity in the watershed. Steep slopes, narrow valleys and limited tillable soils do not lend themselves to agriculture. This land use represents only 5% of the land. Agriculture is concentrated in Guest River C and upper Bear Creek accounting for 10% of each sub-watershed.

2.3 Climate

The area has mild weather year-round, with four distinct seasons. The county's mean temperature in January is 32 degrees Fahrenheit and 70 in July. Average rainfall is nearly 47 inches, while snowfall averages approximately 37 inches annually.

2.4 Water Resources

The following sections describe the monitoring history of the Guest River and tributaries. Guest River has several subsets of monitoring data that have contributed to both the assessment and to the TMDL study results. The data includes ambient monitoring stations and biological monitoring station results based on DEQ staff efforts. There is data resulting from Forest Service staff efforts and citizen monitoring efforts directed and summarized by Tennessee Valley Authority. There is also some United States Geological Survey (USGS) data available and summarized below.

Figure 2.3 shows the location of the monitoring stations from which VADEQ, U.S. Forest Service and U.S.G.S. sample results originate.

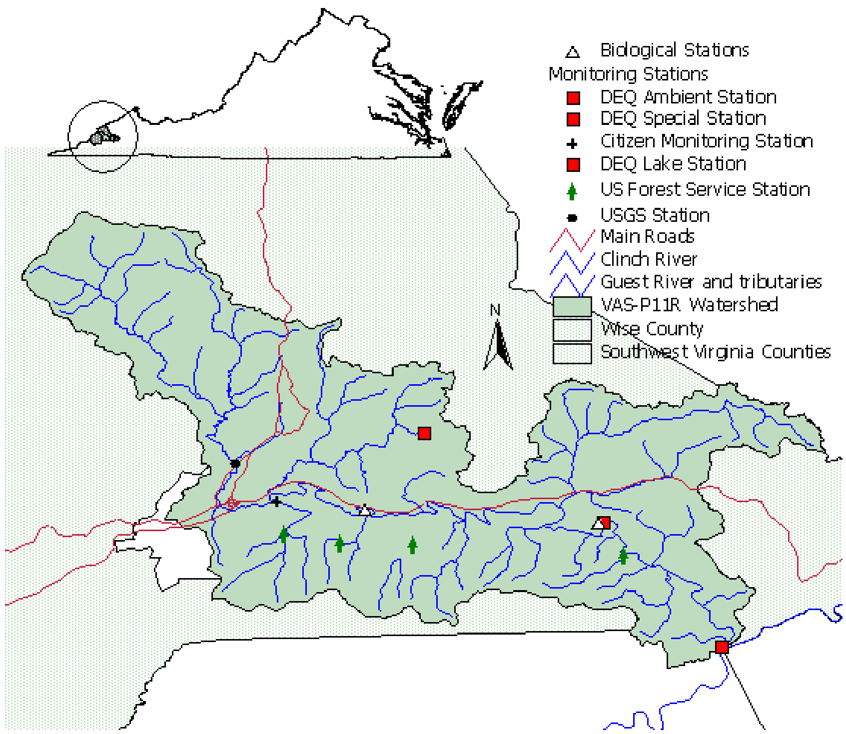


Figure 2.3 Monitoring Station Locations

Biological Monitoring History The biological sampling station location, 6BGUE006.50, was established 6.5 miles from the mouth of the river at the Route 72 bridge crossing over Guest River. On June 17, 1993, the benthic macroinvertebrate community was sampled using a United States Environmental Protection Agency (EPA) approved protocol. The Environmental Protection Agency approved Rapid Bioassessment Protocol 1 allows for identification of benthic macroinvertebrate communities to the Taxa level.

The VADEQ identified the stream as moderately impaired in 1993. The field data showed high periphyton numbers, the habitat was sub-optimal and that there was low density of macroinvertebrates. Field water quality measurements are in Table 2.2 below. These measurements for dissolved oxygen, pH and temperature meet water quality standards. There is no water quality standard for conductivity, however normal surface waters range between 10 and 100 micromhos per centimeter. Guest River partially supported aquatic life use for the 1996 Total Maximum Daily Load Priority List.

In June 2002, the biologist re-visited sampling station 6BGUE006.50, rating the site as moderately impaired using Rapid Bioassessment Protocol 2. The data was compared to a reference stream, South Fork Holston River, to derive a rating. Field parameter measurements recorded at the same time also met water quality standards and are in Table 2.3 below. On May 8, 2002, the biologist established a probabilistic biological monitoring station, 6BGUE016.54, above the community of Tacoma off Alternate Route 58. Sampling results for this new upstream station were rated slightly impaired based on the same reference stream.

Table 2.3 Biological Monitoring Station Field Parameter Measurements on Guest River

Field Parameter	**6BGUE006.50 6/17/93**	**6BGUE006.50 6/11/02**	**6BGUE016.54 5/8/02**
Dissolved Oxygen (milligrams/liter)	8.71	8.26	9.23
pH (Standard Units)	8.24	7.94	7.75
Water Temperature (degrees Celsius)	22.3	21.5	16.7
Conductivity (micromhos/centimeter)	700	646	441

Ambient Water Quality Monitoring History The DEQ ambient water quality monitoring station is located at the same Route 72 bridge as the biological monitoring station (6BGUE006.50). Additionally, the United States Geological Survey gage station that measures flow on the Guest River operated at this bridge for many years. Water quality sampling, at this station, began in March of 1970. Samples were collected monthly until 1992 when the frequency was changed to sample quarterly. In 1996, sampling frequency changed again so sample collection occurred on a bimonthly basis. Current plans are to collect samples at this site for two years of a six-year cycle continuing with the bimonthly frequency.

Parameters measured and reviewed for this study include: turbidity, alkalinity, biological oxygen demand, chemical oxygen demand, volatile solids, total suspended solids, volatile suspended solids, fixed suspended solids, total ammonia, total nitrite, total nitrate, nitrogen TKN, phosphate, total organic carbon, hardness, chloride, sulfate, and phosphate as total orthophosphate. Nutrients and low dissolved oxygen can contribute to benthic impairment. There is no indication that low dissolved oxygen is the reason for impaired macroinvertebrate health. Nutrients are not the stressor here either. Tables depicting the analysis results from 1990 to 2001 are included as Appendix A. Summaries for DO, turbidity and TSS are presented in table 2.4. below.

In 1997, DEQ analyzed sediment and fish tissue samples from the Guest River. Results for total DDT, total PAH and florene did not exceed the Effects Range Median. The fish tissue results exceeded the screening values for mercury in a single species, PCB in two species and Total PAH in a single species.

In 1998, fecal coliform violations resulted in listing the Guest River as a 303(d) segment for failure to support the Swimmable Use. The assessment data included results from Tennessee Valley Authority (TVA) as well as the DEQ sampling results. Fecal coliform violations do not affect aquatic life health. Consequently, this parameter is not the reason for the benthic impairment. Other parameters measured at this location have not violated water quality standards.

In December 2002, the DEQ staff collected water samples for a bioassay series funded by EPA Region 3. Growth/survival of fathead minnows and growth/reproduction of Ceriodaphnia dubia were measured using standard toxicity testing methods. Results of this study indicated no acute effects for either test organism, and subchronic effects on fathead minnow growth were too small to be considered biologically significant.

Table 2.4 Summary Dissolved Oxygen, Turbidity and Total Suspended Solids Data

Station	Measure	DO	Turbidity	TSS
6BGUE000.05	Minimum	7.49 mg/L	0.62 FTU	3.0 mg/L
	Maximum	14.13	80	75.0
	Average	10.44	16.34	15.57
	Count	7	7	7
6BGUE006.50	Minimum	6.85	2.5	2.00
	Maximum	14.35	76	333.00
	Average	11.31	13.94	14.38
	Count	39	21	37

United States Forest Service Monitoring History Approximately 63% of the Guest River watershed is forest. A portion of Guest River watershed is in the George Washington Jefferson National Forest. The United States Forest Service periodically monitors water quality and aquatic life health within the National Forest. Data acquisition and interpretation protocols used by the Forest Service are comparable to those used by DEQ biologists. The DEQ approved the use of Forest Service data for the 2002 assessment of three streams. Two of the sub-watersheds, Burns Creek and Clear Creek, are almost exclusively within the National Forest. In 2002, Burns and Clear Creek were fully supporting the aquatic life use. Table 2.5 lists Forest Service monitoring stations.

Table 2.5. US Forest Service Biological Monitoring Results

Station Identification Number	Location	Assessment
9100	Clear Creek	Fully Supports
9103	Burns Creek	Fully Supports
9104	Burns Creek	Fully Supports
9118	Jaybird Branch	Fully Supports

Tennessee Valley Authority Monitoring History In 1994 and 1996, TVA staff used the Index of Biotic Integrity survey method to determine fish health at twelve sites in Guest River watershed. At the same time, TVA staff formulated an EPT score for the benthic taxa at the same twelve sites. The EPT score is the total count of taxa in the ephemeroptera, plecoptera and trichoptera aquatic insect orders. TVA reported that the fish communities were poor to very poor and that benthic communities were fair to poor. TMDL analysis incorporated this data.

In 1996, TVA established a network of 20 sampling sites to more specifically characterize pollutant loading. Towards that end, TVA stations are at the mouths of all the major tributaries and in the Guest River mainstem upstream and downstream of these major tributaries. The sampling methods and analysis TVA employed are similar to those approved and used by DEQ. Results of this effort are included as Appendix B. A list of station locations is in Table 2.6 below and Figure 2.4 shows the locations of these stations.

Table 2.6. TVA Monitoring Stations

Station ID	**River**	**Mile**	**Landmark**	**Latitude**	**Longitude**
PRP	Guest River	30.3	Lower entrance to Powell River Project	37.0221	82.6645
RT626	Guest River	26.5	Above Rock Fork where Rt.626 crosses Railroad	37.0041	82.6488
RkyFk	Rocky Fork	0.1	At Rock Switch Road bridge downstream of Sepulcher Ck.	36.9796	82.6131
ESSV	Guest River	23.5	At Esserville	36.954	82.6103
Clear	Clear Creek	0.5	At Clear Creek Park in Norton	36.9379	82.5898
Yell	Yellow Creek	0.1	Upstream of confluence with Bear Creek	36.9589	82.5819
Bear	Bear Creek	2.0	At Yellow Creek confluence	36.9552	82.5775
Burns	Burns Creek	0.5	At Burns Creek Road near Tacoma	36.9284	82.5586
TAC	Guest River	13.9	Above Tacoma	36.9354	82.5346
RVRV	Guest River	9.9	Above Toms Creek confluence at race track	36.9385	82.5278
Crnst	Toms Creek	2.3	Highway 72 north of Coeburn	36.9652	82.4678
Toms	Toms Creek	0.6	At Hwy 58 bridge in Coeburn near confluence with Little Toms Creek	36.9455	82.4702
L.Toms	Little Toms Creek	0.1	About 50 yards above confluence with Toms Creek in Coeburn	36.943	82.4631
BTC	Guest River	9.1	Below confluence with Toms Creek	36.9353	82.4738
Pine C	Pine Camp Creek	0.1	On Pine Camp Road near confluence with Guest River	36.9288	82.4846
HWY 72	Guest River	6.3	Above Highway 72 bridge at Coeburn	36.9292	82.4568
Crab O.	Crab Orchard Branch	0.4	At the National Forest near River Road	36.9143	82.435
BTAC	Guest River	13.7	Below Tacoma at private bridge	36.9353	82.4738

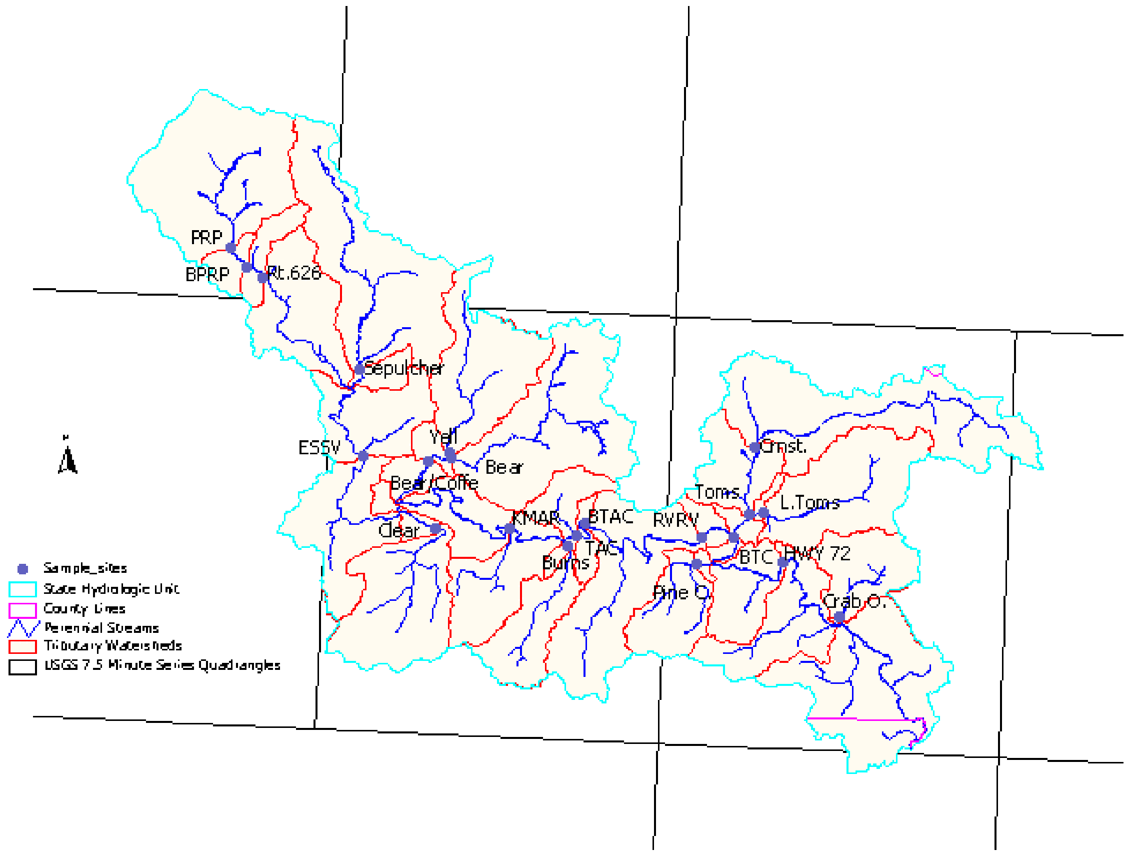


Figure 2.4 Guest River TVA Monitoring Stations Locations

United States Geological Survey Monitoring History United States Geological Survey (USGS) operated two stream flow gages on Guest River. One gage is located at the Highway 72 bridge as mentioned previously. It operated from 1950 until 1998. A second gage station was established at the mouth of Guest River and operated from October 1996 to September 1998.

2.5 Stressor Identification

The general standard is narrative and does not specifically point to the reason that a benthic community is impaired. It is not prescriptive in that there are no specific parameter limits defined that, once met, will insure aquatic community recovery.

TMDLs are required for a specific pollutant. Since a benthic impairment is based on a biological inventory, rather than on physical and chemical water quality parameters, the pollutant is not implicitly identified in the assessment, as it is with physical and chemical parameters. The United States Environmental Protection Agency's (USEPA) Stressor Identification Guidance Document (USEPA, 2000) outlines the process to be used to identify critical stressors. While stream ecology is both dynamic and complex, with many interactions between water chemistry, habitat and organism health, the available data point to sediment as the primary stressor in the Guest River. The evidence supporting sediment as the target pollutant, and the basis for the benthic TMDL for the Guest River, comes from the biologist's determination that poor habitat due to sedimentation prevents the attainment of the aquatic life use.

Sedimentation can eliminate habitat by covering all of the cobble substrate that macroinvertebrates use during their lifecycles. Sedimentation can indirectly lower dissolved oxygen levels in the stream by slowing or short circuiting flow paths so that air is not re-entrained in the water column. Sediment in the water can coat gills of macroinvertebrate populations also. This mechanical action can result in directly smothering the organism or lower their ability to reproduce, thrive, or drive them away from an area.

This finding is supported by the absence of chemical data pointing to another stressor. Taken together, these observations support the case for sediment as the most likely stressor on the benthic community. The TVA's Integrated Pollutant Source Identification (IPSI) tools chosen for the Guest River benthic TMDL study will also allow an estimation of the amount of reduction of sediment loading that is required and feasible in the watershed.

CHAPTER 3

3.0 SOURCE ASSESSMENT

In-stream sediment loads in the Guest River are generated by nonpoint sources such as surface runoff from both pervious and impervious areas as well as channel and road bank erosion, and by point sources (i.e. permitted discharges). Section 3.1. below discusses the permitted discharges in the watershed. In order to identify nonpoint sources of sediment, VADEQ contracted TVA to develop a pollutant loading model based on aerial photography of the watershed. Using photo interpretation methods, TVA staff identified land use categories and then catalogued the number of acres of each land use within the watershed. Based on the land use catalogue, the Universal Soil Loss equation was used to calculate a load, in tons per acre per year, from the watershed. The *Guest River Watershed Nonpoint Source Pollution Inventory and Pollutant Load Estimates* document, prepared by Tennessee Valley Authority (TVA IPSI model), is included as Appendix D. Section 3.2 provides a summary of the nonpoint sources identified through this process.

3.1 Point Sources

DEQ issues Virginia Pollution Discharge Elimination System (VPDES) permits for entities that collect and treat sanitary sewerage and then discharge the treated wastewater to state waters. Since treated wastewater delivery to the stream is usually in a pipe, these are the point sources. The quantity and source of the wastewater determine permit categories. Public sewerage treatment facilities that discharge over one million gallons of treated wastewater each day (mgd) are the major municipal sources. Minor municipal permits are public sewerage treatment facilities that discharge less than one million gallons of treated wastewater each day. Industrial wastewater is a second source. Facilities that discharge industrial wastewater also require permits. Major and minor industrial sources have the same quantity ranges as the municipal sources, that is, a facility discharging one mgd or more is a major source and discharging less than one mgd is minor industrial source. Small family or entity treatment facilities that discharge no more than 1000 gallons each day receive general permits. There is one major municipal source within the watershed, two minor municipal sources and two minor industrial sources. Thirty-five small family home general permit discharges are located here. There are two stormwater permits associated with coal tipples in the Guest River. Table 3.1 lists the discharge permits within the Guest River watershed sorted by the stream to which they discharge.

Table 3.1. VADEQ Permitted Dischargers

Permit No	Receiving Stream	River Mile Location	Maximum Flow (Gallons Per Day)	TSS Concentration Weekly Average (milligrams per liter)	TSS Concentration Monthly Average (milligrams per liter)	TSS Permitted Load (Tons/Yr)
VA0023477	Bad Branch, UT	6BBAS001.08	30,000	45	30	1.4
VAG400020	Bear Ck.	6BBER003.84	1,000	45	30	0.046
VA0030112	Bear Ck., UT	6BXA4000.66	21,800		30	1.00
VAG400060	Bear Ck., UT	6BXCD000.84	1,000	45	30	0.046
VAG400218	Bear Ck., UT	6BXDD000.38	1,000		30	0.046
VAG400234	Bear Ck., UT		1,000		30	0.046
VA0077828	Guest River	6BGUE007.56	4,000,000	45	30	182.70
VAG400265	Guest River	6BGUE025.09	1,000		30	0.046
VAG400266	Guest River	6BGUE025.01	1,000		30	0.046
VAR050097	Guest River		Stormwater	N/A	N/A	0.15
VAR050105	Guest River		Stormwater	N/A	N/A	0.11
VAG400110	Guest River, UT		1,000		30	0.046
VAG400292	Guest River, UT	6BXCD000.38	1,000		30	0.046
VAG400293	Guest River, UT	6BXDC000.38	1,000		30	0.046
VAG400320	Guest River, UT	6BXCF000.25	1,000		30	0.046
VAG400322	Guest River, UT	6BXCE000.48	1,000		30	0.046
VAG400305	Little Toms Ck.	6BLTF003.76	1,000		30	0.046
VAG400357	Little Toms Ck., UT	6BXDK000.11	1,000		30	0.046
VAG400362	Little Toms Ck.. UT	6BXDN000.31	1,000		30	0.046
VAG400318	Parsons Br., UT	6BXCB000.30	1,000		30	0.046
VAG400369	Pine Branch	6BPNB000.33	1,000		30	0.046
VAG400252	Pole Bridge Br.,UT	6AXAU000.17	1,000		30	0.046
VAG400267	Sepulcher Ck.	6BSEP000.99	1,000		30	0.046
VAG400289	Sepulcher Ck.	6BSEP002.39	1,000		30	0.046
VAG400348	Sepulcher Ck.,UT	6BXDH000.31	1,000		30	0.046
VAG400255	Shade Branch, UT	6BXCH000.03	1,000		30	0.046
VA0052388	Toms Ck.	6BTMS005.40	60,000		30	2.74
VAG400197	Toms Ck.	6BTMS003.00	1,000		30	0.046
VAG400246	Toms Ck.	6BTMS002.21	1,000		30	0.046
VAG400247	Toms Ck.	6BXCI000.60	1,000		30	0.046
VAG400300	Toms Ck.	6BLTF002.43	1,000		30	0.046
VAG400294	Toms Ck., UT	6BXCI000.84	1,000		30	0.046
VAG400390	Toms Ck., UT	6BXCI000.86	1,000		30	0.046
VAG400393	Toms Ck., UT	6BXCI000.59	1,000		30	0.046
VAG400019	Yellow Ck.		1,000		30	0.046
VAG400091	Yellow Ck.	6BYLO003.35	1,000		30	0.046
VAG400224	Yellow Ck.	6BYLO003.40	1,000		30	0.046
VAG400229	Yellow Ck.	6BYLO003.23	1,000		30	0.046
VAG400394	Yellow Ck.	6BYLO003.33	1,000		30	0.046
VAG400052	Yellow Ck., UT	6BXDB000.32	1,000		30	0.046
VAG400260	Yellow Ck., UT	6BXCC000.55	1,000		30	0.046
TOTAL						**189.72**

Virginia Department of Mines Minerals and Energy issues National Pollution Discharge Elimination System (NPDES) permits to coal mining companies in this watershed. Coal mining is a historic land use as well as a current land use. In September 2002 there were twenty-six permitted coal discharge points in the watershed. NPDES permits issued by the Department of Mines, Mineral and Energy, stipulate use of erosion and sedimentation control practices. On active mine sites, these practices are constructed and operated with specified sediment limits. The points with discharge limits are included in the TVA model. The permits are in Table 3.2.

Table 3.2. DMME Permitted Dischargers

Company Name	NPDES	MPID	Median Flow (Gpm)	Max Limit TSS (mg/L)	Avg Measured TSS (mg/L)	Permitted TSS Load (Tons/Yr)	TSS Load Measured (Tons/Yr)
Rocky Coal	0081321	2670121	12.5	70	7.0	1.9	0.19
Wise Dock	0080324	2685563	30.0	70	5.25	4.6	0.35
CBS Land	0081169	2570016	0.0	70	0	0	0
Cavalier	0080448	2683643	0.0	70	0	0	0
Lone Wolf	0080695	0002465	0.0	70	0	0	0
ME Coal	0080695	2781533	0.0	70	0	0	0
Natural Fuel	0080269	2680521	0.0	70	0	0	0
Paramont Coal	0080781	2685165	150.0	70	7.11	23.0	2.34
Paramont Coal	0080781	2685166	25.5	70	7.87	3.9	0.44
Paramont Coal	0080782	2685179	12.5	70	13.1	1.9	0.36
Paramont Coal	0080782	2685182	4.0	70	6.6	0.6	0.06
Paramont Coal	0080782	2685187	15.0	70	8.85	2.3	0.29
Paramont Coal	0080849	2685210	25.5	70	7.1	3.9	0.39
Red River Coal	0080044	2680197	95.0	70	16.3	14.6	3.40
Red River Coal	0080084	0001343	0.0	70	0	0	0
Red River Coal	0080514	2680295	0.0	70	0	0	0
Red River Coal	0080514	2680934	7.5	70	3.5	1.1	0.06
Red River Coal	0080514	2680937	0.0	70	0	0	0
Red River Coal	0080624	0001597	0.0	70	0	0	0
Red River Coal	0080624	0001598	0.0	70	0	0	0
Red River Coal	0080624	2686049	225.0	70	7.75	34.5	3.82
Red River Coal	0080624	2686053	50.0	70	7.0	7.7	0.76
Red River Coal	0080624	2686054	7.5	70	4.25	1.2	0.07
Red River Coal	0080632	2685924	0.0	70	0	0	0
Red River Coal	0080711	2685850	95.0	70	5.1	14.6	1.06
Tacoma Fuel	0080954	2559324	77.5	70	5.6	11.9	0.95
TOTAL						**127.8**	**14.6**

3.2 Non Point Sources

Nonpoint sources are those sources that do not discharge from one discrete point, but rather, pollutants are carried to the stream by sheet flow from the surrounding drainage area. Generally, nonpoint sources have no permit limits and good management practices, that can reduce pollutant loadings to streams, are voluntary.

Nonpoint sources for sediment in the Guest River watershed are associated with land uses. Forest activities that can contribute to sediment loads include access roads and trails and timber cuts. Unpaved roads can lead to soils washing off or eroding during rainfalls. Areas exposed to rainfall, with low vegetative cover, have the potential to wash soils to streams. Pasture with poor vegetative cover can erode into the stream. Animals with direct access to streams may contribute to bank erosion by developing paths that act as drainage ways for soils to wash to the stream. Urban activities such as paving over land surfaces and construction of houses and buildings influence the amount of sediment that washes to the stream. Early miners stripped trees and vegetation off the land then dug down to the coal seams that lay near the earth surface. Once the coal was extracted, companies left the land in a condition that encouraged erosion. Legislative changes now require mined lands to be stabilized after mining is complete and during the mining process sediment traps and other best management practices are required.

Once land use categories are identified, each has a different delivery rate to the stream. For example, in urban areas, construction is a common soil disturbing activity. When vegetation is disturbed, rainfall runoff can capture soil and wash the soils to the nearest stream. It can be seen from this example that the more vegetation on a site, then the less chance soils or other pollutants will wash to the stream. Existing loads for land use categories are listed and discussed in the TVA IPSI report. Since all the loadings of the sub-watersheds may ultimately wash to the biological monitoring station where the aquatic organisms impairment was measured, estimates were made in each sub-watershed as well.

Chapter
4

4.0 TMDL Development

A number of methods for determining the target sediment load for the watershed are possible. The method chosen for Guest River TMDL study is the TVA's Integrated Pollutant Source Identification (IPSI) tool. The following sections provide a summary of this method and its use in developing the recommended load reductions and sediment TMDL for the Guest River. The full technical document is included as Appendix D.

4.1 Description of IPSI methodology

The IPSI model requires information about the watershed landscape. Landscape features necessary for the geographic database include land cover (e.g. whether the land is pervious or impervious), streambank erosion, livestock operations and other land use information than affects pollutant delivery to the stream. In order to identify and quantify land use practices, Tennessee Valley Authority photographed the watershed from low altitude aircraft. Color-infrared photography allows photo interpretation of these land uses and inferences about the land cover. The land use and land cover classification scheme used is similar to the United States Geological Survey scheme for remote sensed data. Appendix D provides the reference citations.

Once the photography is interpreted, and the inventory of landscape features is complete, the information is incorporated into a Geographic Information system (GIS). At the same time, the inventory, with associated attributes for each feature, is housed in Microsoft Excel spreadsheets. The Excel Tables are set to calculate pollutant loads using the Universal Soil Loss Equation and other referenced equations. A discussion of the IPSI model calibration is provided in Appendix D, *Guest River Watershed Nonpoint Source Pollution Inventory and Pollutant Load Estimates*. There are three components to calibration of the model; validation of the aerial photo interpretation, land use factor adjustments and comparison of model results to measured data.

The first component verified during the study is the aerial photography interpretation. Basically, the land use data catalogue is from the photo interpretation of aerial infrared photography, during leaf off conditions. Local agency staff compared land use maps generated from the photography and data available from local agencies. For example, coal-mining lands were broken into categories with the help of the Virginia Department of Mines, Minerals and Energy staff and their extensive geographic information system and water quality data. The number of acres of abandoned mine lands, active mines, pasture lands, urban lands and miles of roads in each sub-watershed were refined during this step.

The second calibration effort involved adjusting Universal Soil Loss Equation factors. The Universal Soil Loss Equation uses the annual average rainfall, slope length, soil erodibility, rainfall energy, crop management and erosion control practice factors. The Natural Resources Conservation Service district office and the Department of Mines, Minerals and Energy staff provided factors for erosion control practices. Visual examination of graphs for the relative contributions from each sub-watershed allowed confirmation of assumptions and expectations.

The third calibration effort compares the total suspended solids water quality data to the model results. This comparison is between a regression of median sample concentrations multiplied by the watershed area and modeled loads. The results compared favorably with $R^2 = 0.83$.

4.2 Existing Loads and Endpoint Selection

Because Virginia has no numeric in-stream criteria for sediment, a reference watershed approach was used to set allowable loading rates in the impaired watershed. The reference watershed approach pairs two watersheds: one whose streams are supportive of their designated uses, and one whose streams are impaired. This approach is based on the assumption that reduction of the stressor loads in the impaired watershed to the level of the loads in the reference watershed will result in elimination of the benthic impairment. The reference watershed approach involves selection of an appropriate reference watershed, quantification of the pollutant load in the reference and impaired watersheds, the definition of the TMDL endpoint using the reference watershed load, and development of TMDL allocation scenarios. Using the IPSI model, average loading rates were calculated for all subwatersheds in the Guest River watershed (Table 4.1).

Table 4.1 Guest River Loading Rates and Required Reductions By Subwatershed
(Note: Burns Creek provides the target loading rate for the TMDL)

Watershed Name	Average TSS Loading Rate, tons/acre/ year	% Reduction to Meet Target
Guest River A	0.21	28.10%
Crab Orchard Br.	0.33	54.84%
Guest River B	0.17	14.05%
Pine Camp Cr.	0.20	23.50%
Guest River C	0.54	72.28%
Toms Creek	0.45	66.33%
Little Toms Cr.	0.35	57.45%
Toms Creek	0.31	51.85%
Guest River D	0.31	51.68%
Burns Creek	**0.15**	**3.03%**
Guest River E	0.19	20.55%
Guest River F	0.88	82.93%
Bear Creek	0.55	72.51%
Yellow Creek	0.44	66.11%
Bear Creek	0.43	65.48%
Clear Creek	0.13	-11.99%
Guest River G	0.45	66.31%
Sepulcher Cr.	0.51	70.85%
Guest River H	0.37	59.05%
Guest River I	0.35	57.46%
TOTAL	0.33	54.63%

For the Guest River, two subwatersheds were selected as potential reference watersheds: Burns Creek and Clear Creek. Both watersheds are located in the National Forest and present a very conservative goal for sediment loading rates. They were rated as fully supporting based on National Forest Service data. Since, these watersheds can support aquatic life with a certain level of sedimentation, reduction of sedimentation to the same target level is expected to result in the Guest River also supporting aquatic life.

The two watersheds are located in the same Level III and Level IV ecoregion as Guest River itself. Using the IPSI loading rates, the Burns Creek TSS target of 0.15 tons/acre/year was established for the Guest River watershed. Attainment of this rate would require a 56% reduction of the existing load. The specific TMDL Scenario is summarized in the next section.

4.3 TMDL Scenario

The TMDL, or allowable load, of 9,635.63 tons/year was set as the watershed-based unit area load for Burns Creek (0.15 tons/acre/yr) multiplied by the Guest River watershed area (64,237.5 acres). Retaining the permitted dischargers at their permitted loads of 317.26 tons/year results in an allowable nonpoint source load of 9,318.37 tons/year. Various management scenarios were tested though IPSI to reach this target for the watershed, with the resulting TMDL scenario below. The TMDL reduction scenario is represented graphically in Appendix C.

Using the IPSI model, a TMDL scenario (IPSI Scenario 1) was developed based on the following management actions derived from stakeholder input :

* Repair all abandoned mine features,
* Full cover on 100%of previously mined land,
* 90% reduction of sediment delivery from tipples in Sepulcher Creek,
* 100% overgrazed pasture improved to fair, 75% of fair pasture improved to good,
* Reduce residential urban sources by 60%, all other urban sources by 50%, disturbed areas by 70% and road bank erosion by 50%,
* Repair 1/2 of eroding stream banks,
* Reduce clearcut area load by 25% and improve shrub/scrub areas to 100% cover.

Table 4.2. Guest River TMDL TSS Allocations

Land Use Category	Existing TSS load (tons/year)	% reduction	TMDL TSS allocations (tons/year)
Urban Land [1]	4,666.6	56%	2,038.10
Cropland	7.3	0%	7.30
Pastureland	1,641.9	60%	662.48
Forest Land[2]	4,535.7	2%	4,447.06
Active Strip Mine[3]	17.8	0%	17.80
Tipples	1,323.1	90%	134.15
Previously Mined Land	5,181.8	77%	1,199.95
Abandoned Mine Features[4]	1,943.8	100%	0.0
Disturbed Areas	781.8	70%	234.53
Stream Banks[4]	331.1	50%	165.57
Livestock Access Areas[4]	8.3	0%	8.28
Unimproved Roads[4]	802.2	50%	401.16
Total NPS Load	**21,241.4**	**56%**	**9,315.14**
Permitted Dischargers DEQ DMME	 189.72 127.80	 0% 0%	 189.72 127.80
Total TMDL			**9,632.66**

[1] Urban land reductions consist of 60% reduction on residential land and 50% reduction on all other urban land categories
[2] Forest land reductions consist of 25% reduction on clear cut land
[3] Represented both as NPS load based on land cover and as permitted waste load from DMME dischargers
[4] Represented as linear features in the IPSI model

Table 4.2. shows the resulting TSS loads by aggregated land use category. While the IPSI model allows specific management actions to be simulated, other alternatives may be developed during TMDL implementation.

The sediment TMDL for Guest River is the sum of the three required components - WLA, LA, and MOS - as quantified in Table 4.3. The difference between the TMDL target shown in tables 4.2. and 4.3. is due to the fact that table 4.2. represents the impact of management actions chosen to approximate the TMDL target derived from the reference watershed loading rate (0.15 tons/acre/year).

Table 4.3. Guest River Sediment TMDL (tons/year)

TMDL	WLA	LA	MOS
9,635.63	317.52	9,318.11	implicit

The Margin of Safety is included implicitly in this TMDL because of the following conservative assumptions used in TMDL development: 1) The permitted dischargers typically do not discharge TSS in concentrations near the permit limit. 2) The discharge points from active strip mines are represented as part of the nonpoint source load and also included in the DMME permitted load. 3) The target load is very conservatively based on an unimpacted watershed located in the George Washington National Forest.

4.4 Critical Condition

Because there is usually a significant lag time between the introduction of sediment and nutrients to a waterbody and the resulting impact on beneficial uses, establishing this TMDLs using average annual conditions is protective of the waterbody.

4.5 Seasonal Variability

The RUSLE used in the IPSI model incorporates seasonality into the vegetative cover and rainfall parameters.

Chapter
5

5.0 Implementation and Reasonable Assurance

The goal of the TMDL program is to establish a three-step path that will lead to attainment of water quality standards in the Guest River watershed. The first step in the process is to develop TMDLs that will result in meeting water quality standards. This report represents the culmination of that effort for the benthic impairment on Guest River. The second step is to develop a TMDL implementation plan (IP). The final step is to implement the TMDL, monitor water quality, and determine if water quality standards are being attained.

Once a TMDL is developed and approved by EPA, measures must be taken to reduce pollution levels in the stream. These measures, which can include the use of better treatment technology and the installation of best management practices (BMPs), are implemented in a staged process that is described along with specific BMPs in the Implementation Plan. The process for developing a TMDL implementation plan has been described in the recent "TMDL Implementation Plan Guidance Manual", published in July 2003 and available upon request from the DEQ and DCR TMDL project staff or at http://www.deq.state.va.us/tmdl/implans/ipguide.pdf With successful completion of Implementation Plans, Virginia will be well on the way to restoring impaired waters and enhancing the value of this important resource. Additionally, development of an approved Implementation Plan will improve a locality's chances for obtaining monetary assistance during implementation.

5.1 Staged TMDL Implementation

In general, the Commonwealth intends for the required reductions to be implemented in an iterative process that first addresses those sources with the largest impact on water quality. The staged implementation of BMPs in the watershed has several benefits:

1. As stream monitoring continues, water quality improvements can be recorded as they are achieved;

2. It provides a measure of quality control, given the uncertainties inherent in computer simulation modeling;

3. It provides a mechanism for developing public support;

4. It helps ensure that the most cost effective practices are implemented first; and

5. It allows for the evaluation of the adequacy of the TMDL in achieving water quality standards.

5.2 Stage 1 Implementation Scenario

Watershed stakeholders will have opportunities to participate in the development of the TMDL implementation plan. The IPSI model developed by TVA is a useful tool to develop implementation strategies. The IPSI model provides specific suggestions for management actions that will result in the required load reductions for both the TMDL itself and for interim targets to be achieved incrementally. The control strategies described below can form the basis for a more detailed TMDL implementation plan but alternative practices may be developed during implementation plan development as well.

As an interim implementation goal, the following Stage 1 scenario (IPSI Scenario 2) was developed based on suggestions from the stakeholders in the watershed:

* Repair all abandoned mine features
* Full cover on 50% of previously mined land
* 75% reduction of sediment delivery in Sepulcher Creek
* 50% overgrazed pasture improved to fair, 50% of fair pasture improved to good
* Reduce urban sources by 10%, disturbed areas by 25%, and road bank erosion by 20%,
* Repair 1/3 of eroding stream banks.

The control actions represented in the Stage 1 scenario resulted in the load reductions by land use category shown in Table 5.1. The Stage 1 reduction scenario is represented graphically in Appendix C.

Table 5.1. Stage I Implementation Scenario

Land Use Category	**Existing TSS load (tons/year)**	**% Reduction**	**Stage 1 TSS load (tons/year)**
Urban Land	4,666.6	10%	4,200.6
Cropland	7.3	0%	7.3
Pastureland	1,641.9	26%	1,219.4
Forest Land	4,535.7	0%	4,535.7
Active Strip Mine	17.8	0%	17.8
Tipples	1,323.1	74%	341.7
Previously Mined Land	5,181.8	38%	3,208.1
Abandoned Mine Features	1,943.8	100%	0.0
Disturbed Areas	781.8	25%	586.3
Stream Banks	331.1	18%	270.8
Livestock Access Areas	8.3	0%	8.3
Unimproved Roads	802.2	11%	714.1
Total NPS Load	**21,241.4**	**29%**	**15,110.1**

5.3 Reasonable Assurance For Implementation

A grassroots group is active in the Guest River watershed. Since 1996, the Guest River Restoration Group has completed streambank restoration projects, mine land reclamation and education activities. These activities are a springboard for implementation of the TMDL targets. It is anticipated that reclamation of abandoned mined lands will be part of the initial implementation plan for the Guest River TMDL. One way to accelerate reclamation of abandoned mined lands is through remining. The Virginia Department of Mines, Minerals, and Energy, The Nature Conservancy, The Powell River Project, and the United States Office of Surface Mining have combined resources to develop several incentives to promote economically viable and environmentally beneficial remining. Work groups continue to examine ways to promote remining and to remove obstacles for remining. Based on a study of load reduction via remining completed by the Pennsylvania Department of Environmental Protection (PADEP) and published by EPA, the load reductions proposed in the Guest River initial implementation stage for previously mined lands (38% - listed in Table 5.1) should not present an obstacle for remining in the watershed. When lands are reclaimed through remining and best management practices utilized, the PADEP study indicates that pollution load reductions for several water quality parameters examined averaged approximately 40%.

5.3.1 Follow-up Monitoring

DEQ will continue to monitor Guest River in accordance with its ambient monitoring program. DEQ and DCR will continue to use data from these monitoring stations to evaluate the effectiveness of the TMDL in attaining and maintaining water quality standards. The ultimate measure of success for TMDL implementation is benthic sampling at the Route 72-bridge station (6BGUE006.5). Once at least 60% of the best management practices are in place, the biologist will sample at the station during the spring season. If the aquatic organisms are improving, then a follow-up monitoring effort will occur in the fall. If, however, the benthic community at the station is still impaired, benthic sampling will be suspended until at least 90% of the targeted phase one implementation is in place.

5.3.2 Regulatory Framework

This TMDL is the first step toward the expeditious attainment of water quality standards. The second step will be to develop a TMDL implementation plan, and the final step is to implement the TMDL until water quality standards are attained.

Section 303(d) of the Clean Water Act and current EPA regulations do not require the development of implementation strategies; however, including implementation plans as a TMDL requirement has been discussed for future federal regulations. Additionally, Virginia's 1997 Water Quality Monitoring, Information and Restoration Act directs DEQ in Section 62.1-44.19.7 to "develop and implement a plan to achieve fully supporting status for impaired waters." The Act also establishes that the implementation plan shall include the date of expected achievement of water quality objectives, measurable goals, corrective actions necessary and the associated costs, benefits and environmental impacts of addressing the impairments. EPA outlines the minimum elements of an approvable implementation plan in its 1999 "Guidance for Water Quality-Based Decisions: The TMDL Process." The listed elements include implementation actions/management measures, timelines, legal or regulatory controls, time required to attain water quality standards, monitoring plans and milestones for attaining water quality standards. Watershed stakeholders will have opportunities to provide input and to participate in the development of the implementation plan, which will also be supported by regional and local offices of DEQ, DCR, and other cooperating agencies.

Once developed, DEQ intends to incorporate the TMDL implementation plan into the appropriate Water Quality Management Plan (WQMP), in accordance with the Clean Water Act's Section 303(e). In response to a Memorandum of Understanding (MOU) between EPA and DEQ, DEQ also submitted a draft Continuous Planning Process to EPA in which DEQ commits to regularly updating the WQMPs. Thus, the WQMPs will be, among other things, the repository for all TMDLs and TMDL implementation plans developed within a river basin.

5.3.3 Implementation Funding Sources

One potential source of funding for TMDL implementation is Section 319 of the Clean Water Act. In response to the federal Clean Water Action Plan, Virginia developed a Unified Watershed Assessment that identifies watershed priorities. Watershed restoration activities, such as TMDL implementation, within these priority watersheds are eligible for Section 319 funding. In future years, increases in Section 319 funding will be targeted toward TMDL implementation and watershed restoration. Other funding sources for implementation include the U.S. Department of Agriculture's Conservation Reserve Enhancement Program, the Virginia State Revolving loan Program, and the Virginia Water Quality Improvement Fund. The TMDL Implementation Plan Guidance Manual contains additional information on funding sources, as well as government agencies that might support implementation efforts and suggestions for integrating TMDL implementation with other watershed planning efforts.

Chapter
6

6.0 PUBLIC PARTICIPATION

There was a preliminary meeting with members of the Guest River Restoration Group to discuss the TMDL process and solicit information on April 19, 2001. Jim Hagerman, TVA engineer, discussed his computer model and land use factors. Jutta Schneider and Nancy Norton with DEQ detailed the goals of the study and the information needed to complete the study. This meeting furthered the dialogue between local agencies and TVA to verify that land uses were adequately captured.

A public meeting was on Thursday October 16, 2002. This meeting was at the Tacoma Community Center in the watershed. Notices for the meeting appeared in the October 8, 2002 issues of the Coalfield Progress Newspaper and the Kingsport Times-News. Notice of the meeting also appeared in the Virginia Register and on the DEQ website. About 30 people, including the speakers, attended the meeting. Jim Hagerman presented the IPSI model to the public and discussed reductions that would meet the loads in the forested streams. A 30-day public comment period was open after the public meeting. No written comments were received for this meeting.

Notice of the draft TMDL and solicitation for comments was in the June 30, 2003 issue of the Virginia Register as well as on the DEQ website at http://www.deq.state.va.us/tmdl. Written comments were received from four entities, DCR, DMLR, Coeburn-Norton-Wise Regional Wastewater Treatment Authority and Lonesome Pine Soil and Water Conservation District. These comments were addressed in this draft document. As a result of an article in the Coalfield Progress Newspaper, three telephone calls were received. The telephone calls supported clean water in Guest River and specifically pointed to debris removal as an important goal.

APPENDIX A

Nutrients Analysis Results from 1990 to 2001

Sta Id	Collection Date	AMMONIA, TOTAL (MG/L AS N) #00610 Value	Com Code	NITRATE, TOTAL (MG/L AS N) #00620 Value	Com Code	NITRITE, TOTAL (MG/L AS N) #00615 Value	Com Code	NITROGEN, TOTAL KJELDAHL (MG/L AS N) #00625 Value	Com Code	PHOSPHORUS, IN TOTAL ORTHOPHOSPHATE (MG/L AS P) #70507 Value	Com Code	PHOSPHORUS, ORTHO (MG/L AS P) #00671 Value	Com Code	PHOSPHORUS, ORTHO SUSP (MG/L AS P) #00674 Value	PHOSPHORUS, TOTAL (MG/L AS P) #00665 Value	Com Code
6BGUE000.05	05/28/1997	0.04	U	0.27		0.01	U	0.1		0.02					0.03	
6BGUE000.05	08/20/1997	0.04	U	0.46		0.01	U	0.2		0.03					0.03	
6BGUE000.05	11/20/1997	0.04	U	0.4		0.01	U	0.3		0.12					0.13	
6BGUE000.05	02/18/1998	0.06		0.33		0.02		0.5		0.01					0.06	
6BGUE000.05	05/27/1998	0.04	U	0.52		0.02		0.3		0.02					0.04	
6BGUE000.05	09/28/1998	0.04	U	0.31		0.01	U	0.2		0.05					0.04	
6BGUE000.05	11/23/1998	0.04	U	0.04	U	0.01	U	0.4		0.02					0.02	
6BGUE006.50	01/03/1990	0.06		0.62		0.01	K	0.2				0.02			0.1	K
6BGUE006.50	02/06/1990	0.05		0.64		0.01	K	0.2				0.02			0.1	K
6BGUE006.50	03/07/1990	0.04	K	0.39		0.01	K	0.3				0.01	K		0.1	K
6BGUE006.50	04/03/1990	0.04	K	1.12		0.01		0.2						0.01	0.02	
6BGUE006.50	05/01/1990	0.1		0.26		0.01		0.2				0.01			0.1	K
6BGUE006.50	06/20/1990	0.05		0.29		0.01		0.1				0.01			0.1	K
6BGUE006.50	07/11/1990	0.07		0.19		0.01	K	0.4				0.01			0.1	
6BGUE006.50	08/29/1990	0.04	K	0.19		0.01	K	0.4				0.01			0.1	
6BGUE006.50	09/12/1990	0.11		0.42		0.03		0.6				0.08			0.1	
6BGUE006.50	10/24/1990	0.13		0.4		0.02		0.4				0.03			0.1	K
6BGUE006.50	11/06/1990	0.04	K	0.24		0.01		0.5				0.01			0.1	
6BGUE006.50	12/06/1990	0.18		0.43		0.06		0.5				0.02			0.1	U
6BGUE006.50	01/08/1991	0.04	U	0.56		0.01		0.2				0.02			0.1	U
6BGUE006.50	02/12/1991	0.07		0.46		0.01		0.2				0.02			0.02	
6BGUE006.50	03/20/1991	0.04		0.39		0.01	U	0.3				0.01			0.04	
6BGUE006.50	04/15/1991	0.04		0.27		0.01	U	0.2				0.02			0.03	
6BGUE006.50	05/22/1991	0.06		0.3		0.01		0.3				0.01			0.03	
6BGUE006.50	06/03/1991	0.14		0.34		0.03		0.5				0.03			0.04	
6BGUE006.50	07/09/1991	0.04	U	0.22		0.01		0.4				0.03			0.03	
6BGUE006.50	10/09/1991	0.04	U	0.12		0.04		0.5				0.02			0.05	
6BGUE006.50	02/10/1992	0.04	U	0.62		0.01		0.1		0.01	U				0.04	
6BGUE006.50	05/19/1992	0.04	U	0.53		0.01		0.3		0.01					0.02	
6BGUE006.50	08/12/1992	0.04	U	1.09		0.01	U	0.4		0.04					0.08	
6BGUE006.50	12/07/1992	0.05		0.78		0.01	U	0.1		0.01	U				0.02	
6BGUE006.50	05/13/1993	0.04	U	0.4		0.01	U	0.2		0.01	U				0.01	
6BGUE006.50	08/26/1993	0.04	U	0.42		0.01	U	0.3		0.02					0.03	
6BGUE006.50	11/30/1993	0.2		0.73		0.01		0.3		0.01					0.02	

		AMMONIA, TOTAL (MG/L AS N) #00610		NITRATE, TOTAL (MG/L AS N) #00620		NITRITE, TOTAL (MG/L AS N) #00615		NITROGEN, TOTAL KJELDAHL (MG/L AS N) #00625		PHOSPHORUS, IN TOTAL ORTHOPHOSPHATE (MG/L AS P) #70507		PHOSPHORUS, ORTHO (MG/L AS P) #00671		PHOSPHORUS, ORTHO SUSP (MG/L AS P) #00674	PHOSPHORUS, TOTAL (MG/L AS P) #00665	
		Value	Com Code	Value	Com Code	Value	Com Code	Value	Com Code	Value	Com Code	Value	Com Code	Value	Value	Com Code
Sta Id	Collection Date															
6BGUE006.50	02/23/1994	0.13		0.36		0.04		0.8		0.08					0.24	
6BGUE006.50	05/17/1994	0.04	U	0.41		0.01		0.2		0.01					0.01	
6BGUE006.50	08/24/1994	0.04	U	0.54		0.01	U	0.2		0.01					0.02	
6BGUE006.50	11/30/1994	0.1		0.65		0.01	U	0.3		0.01	U				0.03	
6BGUE006.50	02/14/1995	0.06		0.6		0.01	U	0.1		0.01					0.03	
6BGUE006.50	05/24/1995	0.04	U	0.46		0.01	U	0.1		0.02					0.03	
6BGUE006.50	09/13/1995	0.04		0.71		0.01	U	0.5		0.11					0.13	
6BGUE006.50	11/14/1995	0.07		0.54		0.01	U	0.2		0.03					0.04	
6BGUE006.50	02/26/1996	0.04	U	0.46		0.01	U	0.2		0.01					0.02	
6BGUE006.50	05/21/1996	0.04	U	0.32		0.01	U	0.2		0.01	U				0.02	
6BGUE006.50	08/14/1996	0.04	U	0.6		0.01	U	0.3		0.02					0.04	
6BGUE006.50	11/12/1996	0.04	U	0.44		0.01	U	0.1	U	0.01					0.02	
6BGUE006.50	02/25/1997	0.04	U	0.42		0.01	U	0.1		0.01					0.01	
6BGUE006.50	11/15/1999	0.06		0.71		0.01	U	0.8		0.8					0.03	
6BGUE006.50	01/13/2000	0.16		0.49		0.01		0.4		0.01					0.02	
6BGUE006.50	03/14/2000	0.09		0.36		0.01	U	0.2		0.02					0.01	
6BGUE006.50	05/09/2000	0.04	U	0.34		0.01		0.3		0.02					0.03	
6BGUE006.50	07/12/2000	0.04	U	0.57		0.01		0.4		0.02					0.05	
6BGUE006.50	09/18/2000	0.04	U	0.66		0.01	U	0.3		0.09					0.14	
6BGUE006.50	11/20/2000	0.04	U	0.42		0.01	U	0.3		0.02	U				0.02	
6BGUE006.50	01/23/2001	0.16		0.64		0.01		0.3		0.02					0.02	
6BGUE006.50	03/08/2001	0.15		0.41		0.02		0.3		0.03					0.02	

APPENDIX B

Tennessee Valley Authority Data

TVA Site Description: Guest River at Tacoma

Date	Source	Filterable Residue mg/L TDS	Non-Filt. Residue mg/L TSS
Overall	#Samples		132
1996-2001	MIN.	161	7
	MAX.	659	51000
	MEAN	450	5669
	MEDIAN	530	470
	GEOMEAN		888
1996	#Samples		32
	MIN.		12
	MAX.		28000
	MEAN		6166
	MEDIAN		4650
	GEOMEAN		1740
1997	#Samples		7
	MIN.		31
	MAX.		51000
	MEAN		9438
	MEDIAN		170
	GEOMEAN		621
1998	#Samples		12
	MIN.		44
	MAX.		9800
	MEAN		1287
	MEDIAN		320
	GEOMEAN		387
1999	#Samples		39
	MIN.		31
	MAX.		18000
	MEAN		3712
	MEDIAN		760
	GEOMEAN		984
2000	#Samples		15
	MIN.		58
	MAX.		21200
	MEAN		5574
	MEDIAN		450
	GEOMEAN		1096
2001	#Samples		3
	MIN.		210
	MAX.		13960
	MEAN		4870
	MEDIAN		440
	GEOMEAN		1089

TVA Site Description: Guest River at Hwy 72

Date	Source	Filterable Residue mg/L TDS	Non-Filt. Residue mg/L TSS
Overall	#Samples		64
	MIN	181	**24**
	MAX	1730	**13040**
	MEAN	775	1575
	MEDIAN	536	**225**
	GEOMEAN	596	318
1996	#Samples		15
	MIN.		**24**
	MAX.		**6500**
	MEAN		1260
	MEDIAN		**300**
	GEOMEAN		457
1997	#Samples		16
	MIN.		**26**
	MAX.		**12000**
	MEAN		1011
	MEDIAN		**110**
	GEOMEAN		139
1998	#Samples		5
	MIN.		**70**
	MAX.		**540**
	MEAN		310
	MEDIAN		**330**
	GEOMEAN		256
1999	#Samples		16
	MIN.		**50**
	MAX.		**13000**
	MEAN		2085
	MEDIAN		**160**
	GEOMEAN		347
2000	#Samples		10
	MIN.		**45**
	MAX.		**13040**
	MEAN		3006
	MEDIAN		**485**
	GEOMEAN		710
2001	#Samples		2
	MIN.		**85**
	MAX.		**640**
	MEAN		363
	MEDIAN		**363**
	GEOMEAN		233

TVA Site Description: Guest River above Industrial Park

Period		Q (cfs)	Cond	D.O.	Temp (C)	pH	Cu mg/L	Fe TPTZ mg/L	Mn mg/L	Ni mg/L	Al mg/L	Zn mg/L	SO4 mg/L	NO3 mg/L	PO4 mg/L	Ca mg/L	Mg mg/L	Ca/Mg Hardness mg/LCaCO3	Filterable Residue mg/L TDS	Non-Filt. Residue mg/L TSS
1996-1997																				
	MIN		0.507	6.4	17.5	7.35	0.01	0.29	0.09	0.01	0.05	0.01	160	0.01	0.01	41.6	23.8	202	369	**3**
	MAX		1.14	8.06	18.9	8.1	0.08	1.6	0.67	8	580	0.11	530	0.57	0.03	100	54	510	837	**180**
	MEAN		0.803	7.287	18.39	7.71	0.024	0.995	0.34	4	83	0.02	321	0.27	0.03	65.1	35.8	338.52857	628.6667	50
	MEDIAN		0.735	7.4	18.78	7.66	0.01	1	0.25	4	0.24	0.01	275	0.15	0.03	62	33.5	319.6	680	**8**
	GEOMEAN																			13

TVA Site Description: Sepulcher Creek at RR Crossing

Period		Q (cfs)	Cond	D.O.	Temp (C)	pH	Cu mg/L	Fe TPTZ mg/L	Mn mg/L	Ni mg/L	Al mg/L	Zn mg/L	SO4 mg/L	NO3 mg/L	PO4 mg/L	Ca mg/L	Mg mg/L	Ca/Mg Hardness mg/LCaCO3	Filterable Residue mg/L TDS	Non-Filt. Residue mg/L TSS
1996-1997																				
	MIN	1	0	6	3	5	0	0	0	0	0	0	17	0	0	26	15	125	198	2
	MAX	318	1	12	20	8	5	4	2	0	1	0	403	3	1	92	55	456	735	3600
	MEAN	41	1	9	13	7	1	1	0	0	0	0	133	1	0	42	24	230	397	740
	MEDIAN	7	0	9	14	8	0	1	0	0	0	0	93	1	0	35	20	172	222	360
	GEOMEAN	8	0	9	12	7	#####	1	####	0	####	####	100	0	0	38	22	205	337	189

TVA Site Description: Yellow Creek at Bear Creek

Period		Q (cfs)	Cond	D.O.	Temp (C)	pH	Cu mg/L	Fe TPTZ mg/L	Mn mg/L	Ni mg/L	Al mg/L	Zn mg/L	SO4 mg/L	NO3 mg/L	PO4 mg/L	Ca mg/L	Mg mg/L	Ca/Mg Hardness mg/LCaCO3	Filterable Residue mg/L TDS	Non-Filt. Residue mg/L TSS
1996-1997																				
	MIN	0.65	0.28	6.26	3.54	0.477	0	0	0	0.002	0	0	48	0.01	0.01	29	11	117.7	233	**1**
	MAX	11.71	0.883	11.5	18.31	8.62	258	3.4	0.7	0.196	0.93	0.226	306	4.8	0.51	70	38	370	563	**13000**
	MEAN	3.31347	0.577	9.6	11.57	7.561	16.11	0.497	0.144	0.039	0.16	0.045	149.5	1.418	0.197	47.49	23.46	232.888889	335.6667	2107
	MEDIAN	1.9	0.6	9.57	12.15	7.95	0.01	0.31	0.1	0.008	0.078	0.01	142.5	0.5	0.09	45.5	22	211.1	274.5	**550**
	GEOMEAN	2.29823																		444

Site Description: Burns Creek at Bruns Creek Road

Period		Q (cfs)	Cond	D.O.	Temp (C)	pH	Cu mg/L	Fe TPTZ mg/L	Mn mg/L	Ni mg/L	Al mg/L	Zn mg/L	SO4 mg/L	NO3 mg/L	PO4 mg/L	Ca mg/L	Mg mg/L	Ca/Mg Hardness mg/LCaCO3	Filterable Residue mg/L TDS	Non-Filt. Residue mg/L TSS
	MIN	0.112	0.002	7.42	4.07	5	0	0	0	0	0	0	0	0	0	0.6	0.5	2	10	**1**
	MAX	23.37	0.126	13.4	17.11	7.9	270	107	0.2	0.2	0.4	0.17	256	4.5	2.88	1.2	0.6	5.3	27	**2800**
	MEAN	4.519706	0.029	9.993	10.48	6.625	16.1	6.053	0.05	0.04	0.09	0.04	20	1	0.34	0.9	0.5	4.187778	17.2333	298
	MEDIAN	1.83	0.018	10	10.71	6.5	0.057	0.061	0.02	0	0.05	0.01	6	0.4	0.2	0.9	0.5	4.4	15.7	**10**
	GEOMEAN																			17

Site Description: Toms Creek at Little Toms Creek

Period		Q (cfs)	Cond	D.O.	Temp (C)	pH	Cu mg/L	Fe TPTZ mg/L	Mn mg/L	Ni mg/L	Al mg/L	Zn mg/L	SO4 mg/L	NO3 mg/L	PO4 mg/L	Ca mg/L	Mg mg/L	Ca/Mg Hardness mg/LCaCO3	Filterable Residue mg/L TDS	Non-Filt. Residue mg/L TSS
1996-1997	**MIN**	4.193	0.27	4.76	6.5	5.11	0.01	0.03	0	0	0	0	41	0	0	31	11	129.3	280	**4**
	MAX	26.288	0.9	13	17.6	8.28	5.1	6.2	0.4	0.2	3.1	0.173	183	3.2	0.8	53	22	222.9	380	**30000**
	MEAN	8.83742	0.577	9.8	12.64	7.68	1.142	1.162	0.18	0.05	0.5	0.034	108	0.91	0.227	37.2	15.04	161.75	330	2226
	MEDIAN	6.054	0.574	9.92	13.08	7.94	0.035	0.468	0.2	0	0.15	0.01	108	0.5	0.065	34	13.3	145.85	321	**185**
	GEOMEAN																			190

TVA Site Description: Little Toms Creek near Toms Creek

Period		Q (cfs)	Cond	D.O.	Temp (C)	pH	Cu mg/L	Fe TPTZ mg/L	Mn mg/L	Ni mg/L	Al mg/L	Zn mg/L	SO4 mg/L	NO3 mg/L	PO4 mg/L	Ca mg/L	Mg mg/L	Ca/Mg Hardness mg/LCaCO3	Filterable Residue mg/L TDS	Non-Filt. Residue mg/L TSS
1996-1997	**MIN**	0	0.18	6.98	5	5.32	0.01	0.01	0	0	0	0	20	0.04	0	24	8.1	93.3	130	**4**
	MAX	18.558	0.522	14.11	22.4	8.6	5.17	110	2.4	0.2	57	0.34	100	4.2	1.13	87	20	299.6	192	**2600**
	MEAN	3.1145	0.346	10.75	14.74	7.64	0.931	7.847	0.31	0.06	4.24	0.08	58.5	1.19	0.2	37.8	12	144.7	166.6	595.32
	MEDIAN	2.15	0.36	11.2	16.59	7.87	0.069	0.745	0.2	0.02	0.11	0.02	60	0.59	0.1	28.4	10	121.65	180	**360**
	GEOMEAN																			264

TVA Site Description: Pine Camp Creek at Guest River

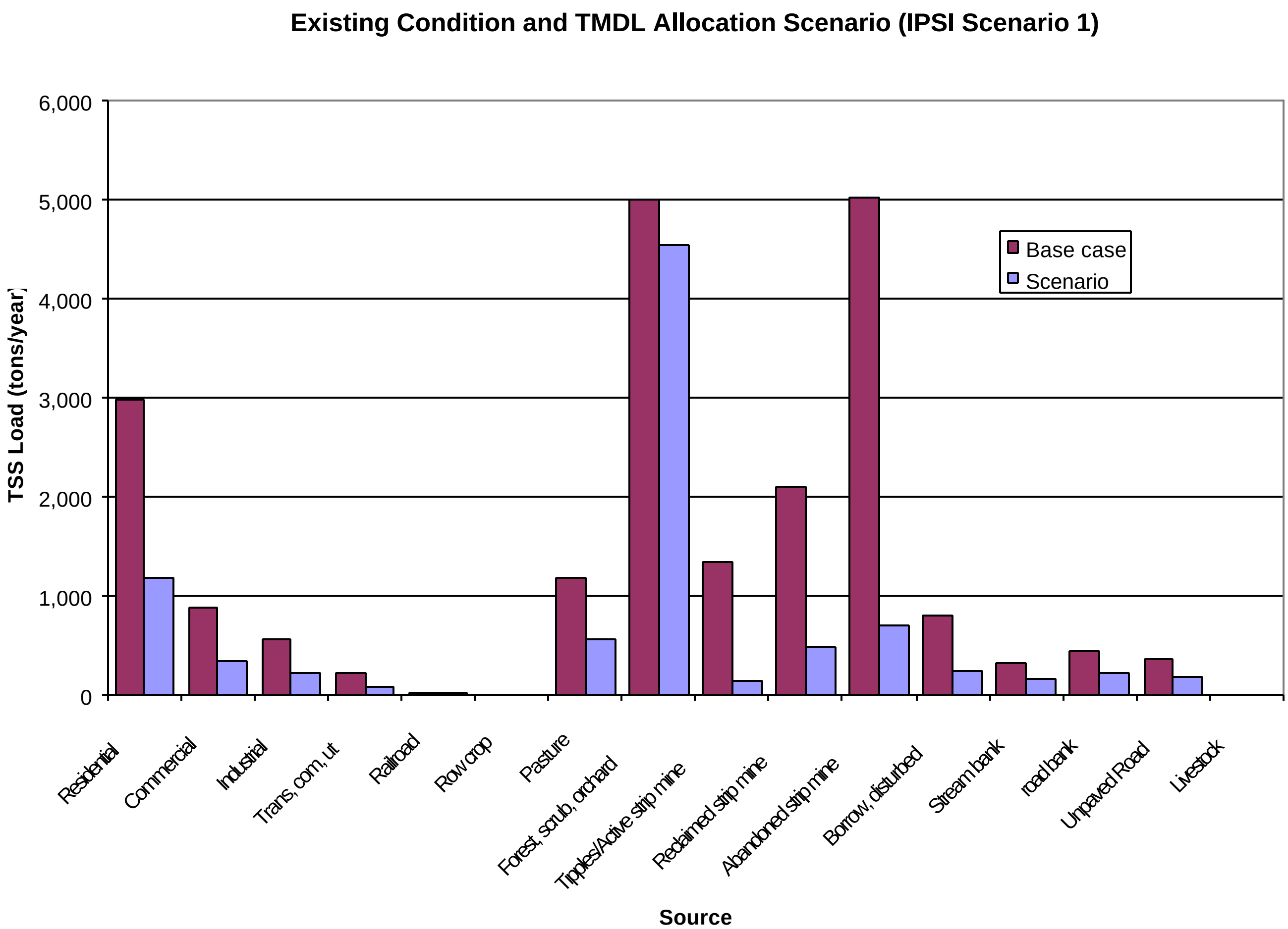
Period		Q (cfs)	Cond	D.O.	Temp (C)	pH	Cu mg/L	Fe TPTZ mg/L	Mn mg/L	Ni mg/L	Al mg/L	Zn mg/L	SO4 mg/L	NO3 mg/L	PO4 mg/L	Ca mg/L	Mg mg/L	Ca/Mg Hardness mg/LCaCO3	Filterable Residue mg/L TDS	Non-Filt. Residue mg/L TSS
1996-1997	**MIN**	0	0.04	5	5	4.75	0.01	0.01	0	0	0	0	0	0	0.01	2.54	1.3	12.3	6	**4**
	MAX	13.2	0.18	16.1	18.2	8	5.35	3.05	0.44	0.2	0.4	0.11	24	3.1	1.75	14	4.1	51.8	102	**2000**
	MEAN	3.13	0.092965	9.992	11.74642857	7.10556	1.065	0.598	0.06	0.04	0.16	0.03	5.89	0.59	0.36	5.66	1.91	22.9875	50	542
	MEDIAN	1.65	0.094	9.34	11.435	7.25	0.057	0.48	0.04	0	0.15	0.01	2.28	0.35	0.19	4.9	1.6	19.85	51	**270**
	GEOMEAN																			151

TVA Site Description: Crab Orchard Branch at National Forest

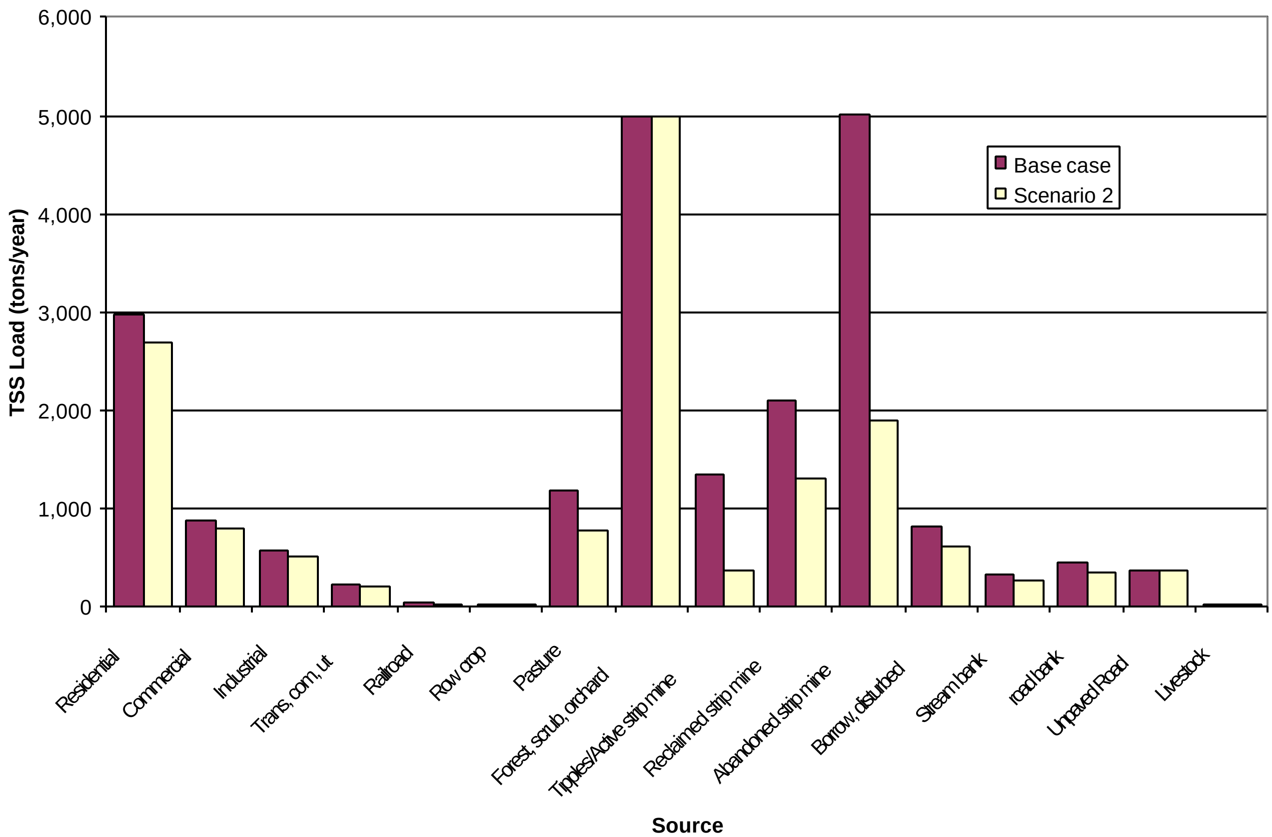
Period	Source	Q (cfs)	Cond	D.O.	Temp (C)	pH	Cu mg/L	Fe TPTZ mg/L	Mn mg/L	Ni mg/L	Al mg/L	Zn mg/L	SO4 mg/L	NO3 mg/L	PO4 mg/L	Ca mg/L	Mg mg/L	Ca/Mg Hardness mg/LCaCO3	Filterable Residue mg/L TDS	Non-Filt. Residue mg/L TSS
1996-1997	**MIN**	0.12	0.0012	5.25	3	7	0	0	0	0.001	0	0	0	0	0	8.2	3.1	33.2	40	**4**
	MAX	16.48	1.106	11	18.1	8	11	37	1	0.196	16	0.15	67	2.9	6.48	31	8.4	107	163	**8200**
	MEAN	2.46473	0.1817	9.03	11.63	7.41	1.591	3.316	0.19	0.041	1.373	0.059	23.4	0.586	0.786	15.6	5.194	62.8375	106.117	1163
	MEDIAN	0.4121	0.121	9.55	12	7.5	0.028	0.735	0.11	0.002	0.085	0.03	21	0.405	0.395	11	4.36	53.3	109.85	**210**
	GEOMEAN																			154

APPENDIX C

Tennessee Valley Authority IPSI Model Scenarios For the Guest River


Existing Condition and TMDL Allocation Scenario (IPSI Scenario 1)
6,000
5,000
4,000
3,000
2,000
1,000
0
TSS Load (tons/year)
Base case
Scenario
Residential
Commercial
Industrial
Trans, com, ut
Railroad
Row crop
Pasture
Forest, scrub, orchard
Tipples/Active strip mine
Reclaimed strip mine
Abandoned strip mine
Borrow, disturbed
Stream bank
road bank
Unpaved Road
Livestock
Source

Existing Condition and Interim Allocation Scenario (IPSI Scenario 2)



APPENDIX D

Tennessee Valley Authority IPSI Report For the Guest River

Guest River Watershed
Nonpoint Source Pollution Inventory
and
Pollutant Load Estimates

Prepared for

Virginia Department of Environmental Quality

by

Tennessee Valley Authority
Chattanooga, Tennessee

September 2002

Revised June, 2003

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Executive Summary

The Tennessee Valley Authority developed a set of Integrated Pollutant Source Identification (IPSI) tools to aid the Virginia Department of Environmental Quality, Office of Pollution Control (VDEQ), to implement water quality improvement and protection within the Guest River Watershed. The tools include a nonpoint source (NPS) inventory, desktop Geographic Information System (GIS), and pollutant loading model.

The NPS inventory is a geographic database that consists of information on watershed features such as land use/land cover, streambank erosion sites, and livestock operations that are known or suspected to be nonpoint pollution sources. The NPS inventory for the Guest River Watershed was generated by interpretation of low-altitude, color-infrared aerial photography taken March 28, 2001.

The desktop GIS is a system that allows the user to investigate relationships among various geographic features that are known or suspected to contribute nonpoint source pollution to a selected waterbody.

The pollutant loading model is a desktop computer model that uses Microsoft Excel software to estimate pollutant loadings based on the data generated by the NPS inventory. This model estimates pollutant loads to the Guest River for total suspended solids (TSS), total nitrogen (TN), and total phosphorus (TP) from the following sources: residential, commercial, industrial, transportation, cropland, pasture, orchards, forest, clear-cuts, mining, disturbed areas, beef cattle, and horses, along with selected linear features such as unpaved roads and eroding stream bank.

The Guest River is a tributary of the Clinch River in southwestern Virginia (Hydrologic Unit Code 06010205-P11). The Guest River Watershed covers 64,244 acres. For reporting and analysis purposes, the Guest River Watershed was divided into 20 subwatersheds.

The Guest River Watershed is predominantly forest (63%). The land use with the next greatest areal extent is current or former mined land (16.1%). Land in all urban and built-up land use categories totals 13.9% of the watershed. Agriculture accounts for

5.2%. Nearly all of this agricultural land is pasture – only 11 acres of crop land were identified. Open water, disturbed and borrow areas, scrub/shrub, and wetlands combine to make up 3% of the watershed.

Most of the beef cattle sites were relatively small.. There were no dairy, swine, or poultry operations identified. There were 20 horse sites identified, and all but one were classified as small.

The remote sensing process identified 150 miles of perennial streams within the Guest River Watershed and another 145 miles of intermittent streams. Excessive streambank erosion and the quality of the riparian buffer was identified for these streams. The Little Toms Creek, Yellow Creek, and Guest River headwater subwatersheds all have conspicuously high percentages of inadequate riparian buffer and large total lengths.

There are 954 miles of road within the Guest River Watershed, including 684 unpaved miles and 270 paved miles.

The total imperviousness for the Guest River Watershed is 5.7%. Five of the 20 subwatersheds exceed 10% imperviousness, and therefore would be considered “impacted”. These watersheds are lower Toms Creek, Yellow Creek, and three Guest River local drainages, Pine Creek to Toms Creek, Bear Creek to Clear Creek, and Clear Creek to Sepulcher Creek. No subwatersheds exceed the “degraded” threshold of 25% impervious.

The pollutant loading model provides an estimate of total loads and the relative contribution of different land uses. Total Suspended Solids (TSS) load is estimated at about 21,000 tons per year for the Guest River Watershed. Previously mined land and urban areas appear to be the most significant contributors. Approximately 109 tons per year of Total Nitrogen (TN) are generated in the watershed. Previously mined land, urban land uses, and agriculture appear to be the most significant sources. Total Phosphorus (TP) load is estimated at 30 tons per year. Residential and other urban land uses appear to be the greatest contributor.

Introduction

The Virginia Department of Environmental Quality (VDEQ) is responsible for the identification of state waterbodies not meeting designated uses and the development of total maximum daily loads (TMDLs) for those waterbodies as required by Section 303(d) of the Clean Water Act and the Environmental Protection Agency's (EPA) Water Quality Planning and Management Regulations (40 CFR part 130). VDEQ contracted with the Tennessee Valley Authority (TVA) to produce Integrated Pollutant Source Identification (IPSI) products for the Guest River Watershed.

IPSI is a geographic database and set of tools for a watershed designed to aid water quality agencies, such as VDEQ, implement the water-quality-based approach to pollution control. The geographic database consists of information on watershed features such as land use/land cover, streambank erosion sites, and livestock operations that are known or suspected to be nonpoint pollution sources. This information is generated by interpretation of low-altitude, color-infrared aerial photography. TVA has used aerial remote sensing techniques, developed over the last 15 years, to provide reliable, high resolution land use and nonpoint source (NPS) pollution information in several watersheds. The data are managed using commercially-available GIS software. The corresponding set of tools includes atlases that summarize and display the information about nonpoint pollution sources within the watershed, a desktop GIS that allows the user easy access to the database, and a computer model for estimating pollutant loadings by sources and tributary watersheds.

The desktop GIS uses ArcView software, developed and supported by Environmental Systems Research Institute, Inc. (ESRI), for managing and viewing the data generated by the NPS inventory. The desktop GIS is a mapping system that allows the user to investigate relationships among various geographic features that are known or suspected to contribute nonpoint source pollution to a selected waterbody. For example, the user can examine the proximity of different nonpoint sources of pollution to waterbodies of interest. The IPSI Desktop GIS can be used to target specific sources and sites for pollution reduction, prioritize subwatersheds for protection and cleanup, track implementation of best management practices (BMPs), and assist in designing and managing water quality monitoring programs to evaluate the effectiveness of BMPs.

TVA used the desktop GIS to summarize and analyze the data generated by the NPS inventory.

The IPSI Pollutant Loading Model (PLM) is a computer model that uses Microsoft Excel to estimate pollutant loadings based on the data generated by the NPS inventory. Default parameter values are from the literature and from experience using the model (for example, Morgan County Soil and Water Conservation District, 1995). Parameters are then tailored to local conditions, and calibrated where monitoring data are available. The model allows the user to estimate pollutant loadings by (sub)watershed and source. It also allows the user to determine changes in pollutant loadings with changes in management practices. TVA used this model to estimate pollutant loads to the Guest River for total suspended solids (TSS), total nitrogen (TN), and total phosphorus (TP).

This report is submitted to fulfill the requirements of VDEQ Contract Number 01RE3-270474. The report documents the remote sensing methods used to produce the NPS inventory and summarizes the data from the NPS inventory. The report also describes the pollutant loading model and summarizes estimated pollutant loads for the Guest River Watershed.

Description of the Watershed

The Guest River is a tributary of the Clinch River in southwestern Virginia (Hydrologic Unit Code 06010205-P11). The confluence of the two streams is at Clinch River Mile 244.2. The Guest River Watershed covers 64,244 acres almost entirely in Wise County, with minor areas in Scott and Dickenson counties.

The Guest River watershed is in the Appalachian Plateaus physiographic province. This area consists of flat-lying or gently dipping strata of Pennsylvanian-age sandstone, shale, and coal. This region has been dissected by geologic erosion into an area of high relief and dendritic stream drainage patterns with uniformly steep-sided valleys. Average elevation of the Appalachian Plateaus in Virginia is between 2000 and 2500 feet. The Appalachian Plateaus are the source of coal, Virginia's most valuable mineral resource. Virginia's coal production has averaged over one billion dollars annually for the last twenty years. (DMME)

About two thirds of the watershed is forested. Mine land, including active mines and formerly mined land, occupies significant land area. The watershed includes the communities of Norton, Wise, and Coeburn. There is little agriculture; most of this is pasture.

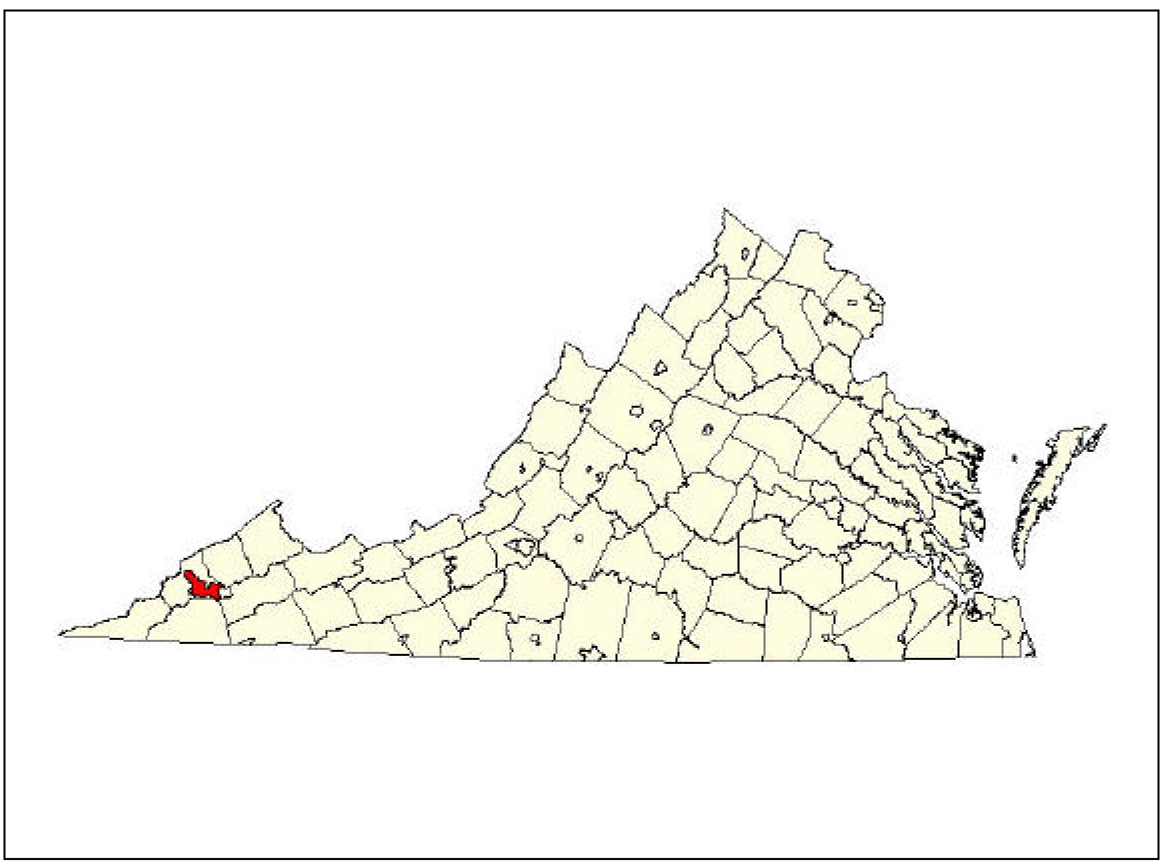


Figure 1. Location of Guest River Watershed

Methods and Summary

The purpose of this project is to develop an inventory of potential sources of nonpoint pollution within the Guest River Watershed. Color infrared aerial photography was used to remotely gather data about the land surface. This data was analyzed and processed into a unique database for the Guest River Watershed. In the absence of stream water quality data, the inventory data can be used as surrogate indicators for potential stream impacts associated with NPS activities. By coupling the remotely-sensed data with a Geographic Information system (GIS), the data can be analyzed for selected areas and incorporated into decision-making and problem-solving processes. A GIS is a computer system designed to allow the users to collect, manage, and analyze large volumes of spatially-referenced and associated data. GIS's are used for solving complex research, planning, and management problems. The major components of a GIS are: a user interface, system/database management capability, database creation/data-entry capacity, spatial data manipulation and analysis package, and display generation function. The GIS software package used for this database was ESRI's ARC/INFO software.

A desktop GIS based on ESRI's ArcView software was constructed for managing and viewing the data generated by the NPS inventory. The desktop GIS provides a user-friendly means to investigate relationships among various geographic features that are known or suspected to contribute nonpoint source pollution to a selected waterbody. The desktop GIS can also be used to target specific sources and sites for pollution reduction, prioritize subwatersheds for protection and cleanup, track implementation of BMPs, and assist in designing and managing water quality monitoring programs to evaluate the effectiveness of BMPs.

A model was developed for estimating pollutant loads to the Guest River from the various nonpoint sources inventoried. Pollutant load is defined as the amount of a particular pollutant delivered to a waterbody over a specific time period from a specific source. The model uses Excel spreadsheet software. The model was used to estimate nonpoint source pollutant loads for total suspended solids (TSS), total nitrogen (TN), and total phosphorus (TP). The model can also be used to demonstrate the effect of potential nonpoint source management strategies on pollutant loads.

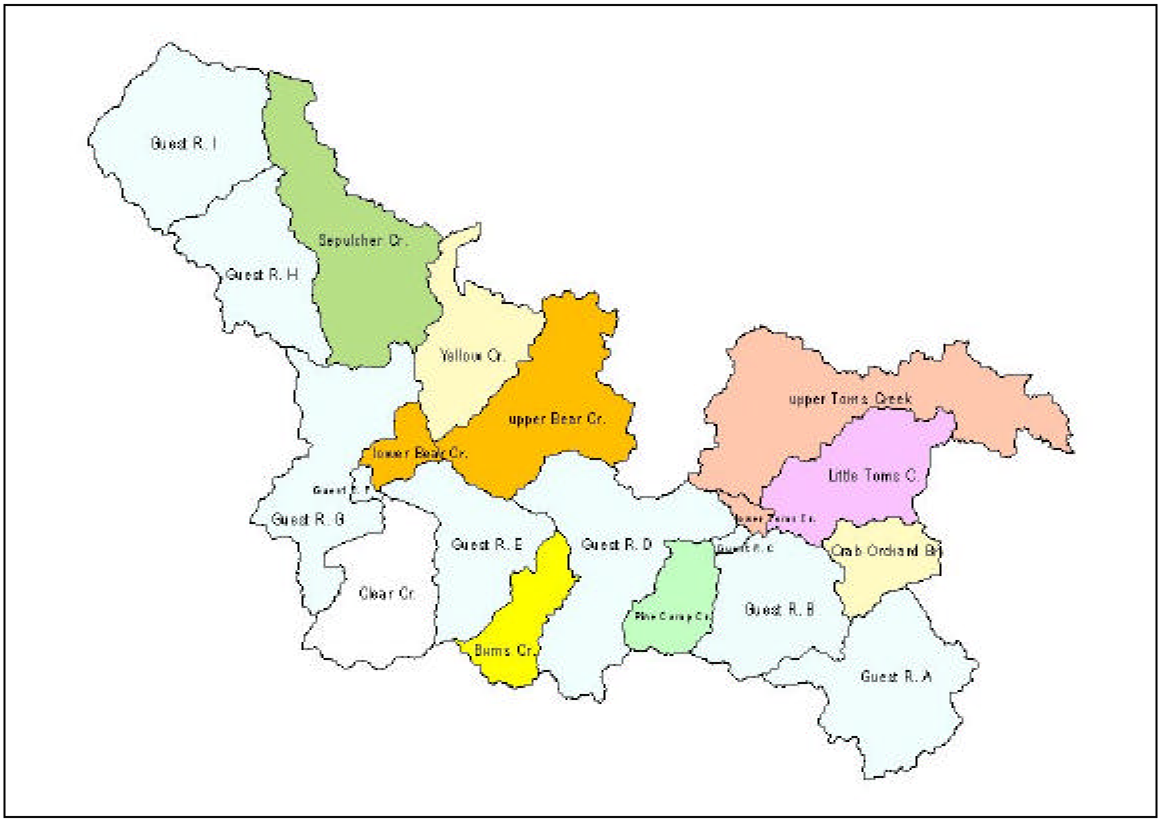
The remote sensing technology used for generating the nonpoint source inventory and the data layers included in the GIS are described in this report. Also described are the assumptions and equations used in the pollutant loading model.

Aerial Photography Acquisition

Aerial photography provides an alternative means to view, interpret, and understand natural and altered features and their complex relationships.

The flight plan parameters were determined by analysis of project requirements. Considerations such as season, weather conditions, time of day, scale, and film type (color infrared, normal color, or black and white) were considered. For this project, vertical aerial photographs were taken on March 28, 2001. The photograph scale was 1:24,000. The exposures were overlapping to enable the interpreter to use specialized equipment to view the landscape in three dimensions. The film type or emulsion was color infrared (CIR). The makeup of CIR film is unique in that one of the three layers of the film's emulsion is sensitive to the near infrared portion of the light spectrum. Because the film is sensitive only to the near infrared portion of the spectrum, and not the longer wavelength emitted or thermal portion of the spectrum, it provides information to the interpreter that is not part of the normal visible spectrum of the human eye. The near infrared is particularly important in assessment of vegetation condition. The chlorophyll of plants is highly reflective in the near infrared. This characteristic allows the interpreter to make inferences on the vigor and type of vegetation not possible with color or black and white film.

Figure 2. Subwatersheds of the Guest



Hydrologic Unit and Subwatershed Mapping

A hydrologic unit is a hydrologically distinct area within the greater project area. The unit defines either the area contributing to the surface runoff at a defined point on a stream (a tributary confluence, sampling site, stream gage, or accessible point for future sampling), or the areas that drain to the main stream that are left over when tributary subwatersheds are defined.

Initially, the Guest River watershed was divided into 40 hydrologic units (Table 1). Many of these were broken out at water quality sampling sites. These units were assigned an identification number, with main stem subwatersheds given sequential two-digit numbers 01 through 18 from mouth to head. Tributaries were given four-digit identifiers, the first two digits indicating the location of the confluence with the main stem, and the latter digits indicating the position on the tributary. For example the mouth of 0501 is between main stem subwatersheds 05 and 06, and 0501 is downstream of 0502. Tributaries of tributaries have two additional digits using the same logic.

Table 1. Subwatersheds of the Guest (original set)

Subwatershed name	County	Subwatershed ID	Area, acres
Guest River, Mouth to Crab Orchard Branch	Scott/Wise	01	4544.9
Guest River, Crab Orchard Branch to Sample Site at Highway 72 Bridge	Wise	02	2202.2
Crab Orchard Branch, Mouth to Sample Site by River Road	Wise	0201	19.8
Crab Orchard Branch, Sample Site by River Road to Head	Wise	0202	1695.2
Guest River, Sample Site at Highway 72 Bridge to Pine Camp Creek	Wise	03	1424.5
Guest River, Pine Camp Creek to Sample Site Below Toms Creek	Wise	04	146.1
Pine Camp Creek, Mouth to Sample Site Downstream from Mill Creek Confluence	Wise	0401	107.2
Pine Camp Creek, Sample Site Downstream from Mill Creek Confluence to Head	Wise	0402	1581.7
Guest River, Sample Site Below Toms Creek to Toms Creek	Wise	05	5.7
Guest River, Toms Creek to Sample Site Downstream from Guest River Mile 10	Wise	06	365.2
Toms Creek, Mouth to Little Toms Creek	Wise	0601	270.2
Toms Creek, Little Toms Creek to Sample Site at Highway 58 Bridge	Wise	0602	1.9
Little Toms Creek, Mouth to Sample Site Downstream from Highway 72 Bridge	Wise	060201	141.2
Little Toms Creek, Sample Site Downstream from Highway 72 Bridge to Head	Wise	060202	3375.8
Toms Creek, Sample Site at Highway 58 Bridge to Sample Stite Below Cranes Nest	Wise	0603	1494.8
Toms Creek, Sample Site Below Cranes Nest to Head	Dickenson/Wise	0604	5268.2
Guest River, Sample Site Downstream from Guest River Mile 10 to Sample Site Below Tacoma	Wise	07	3879.4
Guest River, Sample Site Below Tacoma to Sample Site at Route 706 Bridge	Wise	08	392
Guest River, Sample Site at Route 706 Bridge to Burns Creek	Wise	09	863.4
Guest River, Burns Creek to Sample Site at Bridge to Kenmar Coal Company	Wise	10	2025
Burns Creek, Mouth to Sample Site at Burns Creek Road Crossing	Wise	1001	123.6
Burns Creek, Sample Site at Burns Creek Road Crossing to Head	Wise	1002	1700.1
Guest River, Sample Site at Bridge to Kenmar Coal Company to Bear Creek	Wise	11	1334.8
Guest River, Bear Creek to Clear Creek	Wise	12	180.4
Bear Creek, Mouth to Sample Site at Bridge to Coffee Farm	Wise	1201	494.3
Bear Creek, Sample Site at Bridge to Coffee Farm to Yellow Creek	Wise	1202	332.7
Bear Creek, Yellow Creek to Sample Site Upstream From Yellow Creek Mouth	Wise	1203	6.3
Yellow Creek, Mouth to Sample Site Upstream From Mouth	Wise	120301	9.2
Yellow Creek, Sample Site Upstream From Mouth to Head	Wise	120302	3145.2
Bear Creek, Sample Site Upstream From Yellow Creek Mouth to Head	Wise	1204	4756.4
Guest River, Clear Creek to Sample Site at Highway 23 Bridge	Wise	13	2544.2
Clear Creek, Mouth to Sample Site at Clear Creek Park/Norton	Wise	1301	230.1
Clear Creek, Sample Site at Clear Creek Park/Norton to Head	Wise	1302	3243.2
Guest River, Sample Site at Highway 23 Bridge to Sepulcher Creek	Wise	14	2053.2
Guest River, Sepulcher Creek to Sample Site at Route 626 Bridge	Wise	15	2546
Sepulcher Creek, Mouth to Sample Site at Rock Switch Road Bridge	Wise	1501	435.2
Sepulcher Creek, Sample Site at Rock Switch Road Bridge to Head	Wise	1502	5187.6
Guest River, Sample Site at Route 626 Bridge to Sample Site Below Powell River Project	Wise	16	655.2
Guest River, Sample Site Below Powell River Project to Sample Site at Powell River Project	Wise	17	460.5
Guest River, Sample Site at Powell River Project to Head	Wise	18	5001.5

For subsequent analysis and reporting, these 40 subwatersheds were combined into 20 more intuitive subwatersheds (Figure 2 and Table 2). Each major tributary to the Guest is broken out into at least one subwatershed. Local drainage areas to the Guest are divided at these subwatersheds, and tributary subwatersheds are divided at secondary tributary subwatersheds where the secondary tributary watersheds are large enough to consider separately. Subwatersheds range in size from 152 acres (Guest River C, a local drainage to the Guest between two major tributaries) to 6762 acres (the upper Toms Creek subwatershed). Median subwatershed size is 3500 acres.

Table 2. Reduced set of Guest River subwatersheds used for reporting

Subwatershed name	County	Subwatershed ID	Area, acres
Guest River A	Scott/Wise	01	4544.9
Crab Orchard Br.	Wise	0201, 0202	1715
Guest River B	Wise	02, 03	3626.7
Pine Camp Cr.	Wise	0401, 0402	1688.9
Guest River C	Wise	04, 05	151.8
lower Toms Creek	Wise	0601	270.2
Little Toms Cr.	Wise	060201, 060202	3517
upper Toms Creek	Dickenson/Wise	0602, 0603, 0604	6764.9
Guest River D	Wise	06, 07, 08, 09	5500
Burns Cr.	Wise	1001, 1002	1823.7
Guest River E	Wise	10, 11	3359.8
Guest River F	Wise	12	180.4
lower Bear Cr.	Wise	1201, 1202	827
Yellow Cr.	Wise	120301, 120302	3154.4
upper Bear Cr.	Wise	1203, 1204	4762.7
Clear Cr.	Wise	1301, 1302	3473.3
Guest River G	Wise	13, 14	4597.4
Sepulcher Cr.	Wise	1501, 1502	5622.8
Guest River H	Wise	15, 16, 17	3661.7
Guest River I	Wise	18	5001.5

Land Use and Land Cover Methods

The Guest River Watershed was divided into unique polygons based on land use and land cover (LU/LC) as interpreted from the aerial photograph. Each polygon was assigned a LU/LC code. Table 3 provides a list of the land uses and land covers discernable from aerial photography in the Guest River Watershed. Mapping provides a baseline characterization of the watershed and allows relationships between land use and water quality impairment to be evaluated. The classification scheme used was a hierarchical system based in part on the classification developed by the United States Geological Survey (USGS) for use with remotely sensed data (Anderson, et al.). The classification system was tailored to the Guest River Watershed while maintaining the ability to aggregate the land cover to Anderson Level 1 or 2 classes.

Land Use and Land Cover Summary

Table 11 andTable 12 and Figure 3 andFigure 4 show the general land use/land cover for the Guest River Watershed.

The watershed is predominantly forest (63%). Only one subwatershed (Guest River F [see Figure 2 and Table 2 for descriptions of the subwatersheds]) is less than 30% forest. Burns Creek and Clear Creek are nearly entirely forested (97% and 98%, respectively), and Guest River A, Guest River B, Pine Camp Creek, and Guest River E are each greater than 80% forest.

The next largest land use is mine land (16%). Guest River F and Guest River I are between 50% and 60% mine land, and the two Bear Creek subwatersheds, Guest River H, and Sepulcher Creek are all 20% to 25% percent mine land.

Urban land uses occupy 13.9% of the land area, with most of that (9.6%) in residential land uses. The lower Toms Creek subwatershed is almost two thirds (64%) urban and built up land, and Guest River C is over half (53%) urban.

Agriculture is a minor land use in the Guest, with only 5% of the land. Nearly all of that is pasture. The greatest concentration of agricultural land is in the Guest River C subwatershed and the upper Bear Creek subwatershed, each with just over 10% agriculture.

Table 3. Land Use Classification for the Guest River Watershed

1. Urban and built-up
    - 11. Residential
        - 111. Single family, medium density (more than 6/acre)
        - 112. Single family, low density (fewer than 2/acre)
        - 115. Apartment/condominium complex
        - 117. Mobile home park
    - 12. Commercial, service, institutional
        - 1204. Auto junkyard
        - 1207. Golf course
        - 1210. Race course
        - 1219. Parking lot
        - 1221. Athletic field
        - 1224. Commercial, service, institutional
        - 123. Service
        - 1235. Water treatment
        - 1236. Sewage treatment
        - 1237. Water tank
        - 1251. Educational
        - 1253. Religious
        - 1255. Cemetery
    - 13. Industrial
    - 14. Transportation
        - 140. Airport
        - 141. Railroad
        - 142. Major highway right-of-way
        - 144. Dam
        - 145. Electric transmission right-of-way
        - 1461. Substation
        - 1491. Natural gas well
2. Agriculture
    - 21. Cropland and Pasture
        - 2101. Row crop: no residue (0 to 10%)
        - 2104. Row crop: medium residue (10 to 30%)
        - 213. Fair pasture: uneven growth and condition, minimal maintenance
        - 215. Heavily overgrazed pasture
    - 22. Orchards, Vineyards, and Nurseries
    - 32. Shrub and brush: old field with volunteer woody growth
4. Forest land
    - 45. Harvested forest land
5. Water
7. Barren land
    - 75. Strip mines, Deep mines, Quarries, and Borrow areas
        - 750. strip mine
            - 7501. Active
                - 75011. Bench (contour)
                    - 750102. Tipple
                    - 750105. Flooded
                    - 750108. Valley Fill
            - 7502. Previously mined
                - 75021. Sites with highwall; considered to be abandoned
                - 750216. Slide area associated with highwall sites
                - 75022. Reclaimed to approximate original contour with no prominent highwall, usually adequate vegetation
                - 750226. Slide area
            - 7503. Other abandoned mine area
        - 753. Borrow area
            - 7531. Active
    - 76. Disturbed area: little or no cover, non-agricultural area

<u>Wetland Classification</u>

PEM.	Palustrine emergent
PFO.	Palustrine forested
PFO/SS.	Palustrine forested/scrub-shrub
PSS.	Palustrine scrub-shrub
PSS/EM.	Palustrine scrub-shrub/emergent

Livestock Operations Methods

Livestock operations were mapped by interpretation of facilities and their relationships or associations with the landscape. Examples of the relationships are soil compaction, soil staining, soil moisture content, size and presence of barns and other structures, presence of hay bales, animal trails, water sources, fencing, and feedlots. These relationships and associated land cover were used to determine the relative size and type of livestock operation. Other potential impacts identified include proximity to streams; whether a site has critical impact factors, such as a large concentration of animals, poor or no waste management; presence of waste management ponds or lagoons; and whether the animals are confined. The type of operation was identified by looking at clues such as exercise rings for horse operations, silos and loafing areas at dairies, and large open pastures for cattle operations.

Livestock Operations Summary

Table 13 shows the number and of beef cattle sites within the Guest River Watershed, their size (small, medium, or large) and whether they are adjacent or nonadjacent to the stream. There were 77 beef cattle sites identified in the Guest River Watershed, 42% of which were adjacent to a perennial stream. None of the sites was classified as a large operation. Most (86%) were classified as small.

The classification of small, medium, or large as reported here is a relative relationship among sites within the Guest River Watershed (Table 9). The classification is assigned by the photo interpreter and is for the purpose of comparing potential water quality impacts among sites and watersheds. It is not consistent with any regulatory definitions regarding livestock operations.

The locations of the beef cattle sites, along with the horse sites, are shown in Figure 5. The greatest concentration is in the upper Toms Creek subwatershed, with 15 sites.

Table 14 shows the number of horse sites within the Guest River Watershed (see Table 10 for size definitions). There were 20 horse sites identified in the Guest River Watershed, and all but one were classified as small operations. Two operations are adjacent to a perennial stream. The greatest concentration of horse sites is in the upper Toms Creek subwatershed and the Yellow Creek subwatershed, each with 5 sites.

Stream Network and Order

The stream network is based on the blueline streams from the 7½ minute USGS maps. The streams were entered into the GIS either by loading the USGS Digital Line Graphics (DLG) or by digitizing the stream network from the maps. This base level of streams was then enhanced based on the photo interpretation. Streams were added or alignment modified as appropriate to accommodate loading of the photo-interpreted information.

Strahler stream order is a number representing a stream's relationship to the overall stream network of a watershed. Headwater tributaries are first-order streams. The convergence of two first-order streams creates a second-order stream. A third-order stream results when two second-order streams converge. This numbering continues until all the streams of a watershed are ordered. The order of streams is based on the blueline stream network on the standard 7½ minute 1:24,000 scale, USGS topographic map series.

Drainage Conditions

Pollutants from nonpoint sources enter the aquatic environment through surface runoff and groundwater seepage. Drainage conditions associated with the various land uses and livestock operations were mapped and included in the GIS database. The drainage features mapped are listed in Table 5.

Riparian Features and Conditions Methods

Characteristics determined from aerial photography include extent of streambank erosion and riparian condition. The riparian condition in the NPS inventory is a characterization of the land cover buffer adjacent to a stream. Benefits of a well-managed riparian buffer include: helping prevent erosion of banks; filtering nutrients, soil, and pesticides from runoff before it enters the water; providing food and habitat for stream life; and contributing to the microclimate within the waterway by providing shade. The only riparian feature that was used in the loading model was eroding stream bank.

The riparian conditions are mapped in two landscape categories. The first is an open landscape referring to areas lacking appreciable woody vegetation. The stream is adjacent to grass, bare ground, or urban land cover. The second is a closed landscape referring to areas being dominated by woody vegetation. The following riparian buffer features were mapped for the left and right (looking downstream) banks of perennial streams: vegetative type, the percent of coverage of the vegetative type, the quality of the vegetative cover and the width of the vegetation. Vegetative type was identified as either woody, grass, or bare. Percent of coverage was identified as 0 to 33%, 34 to 66%, or 67 to 100% for woody vegetation. Grass cover quality was rated as poor, moderate, or good. The width of vegetation was identified as 0 to 25 feet, 26 to 100 feet, or greater than 100 feet. Photo-identifiable physical features in the stream were mapped including riffles, falls, ponds, and pools.

A riparian buffer classification matrix (Table 4) was used to rate the ability of the riparian buffer to filter rainfall runoff before entering the stream. The assumption is that the quality and extent of the buffer zone has a direct relationship to the potential ecological health and water quality of a stream by reducing nonpoint source pollutants entering the stream. The riparian buffer was rated as adequate, marginal, or inadequate with regard to the ability to remove pollutants.

Riparian Features and Stream Bank Condition Summary

The remote sensing process identified 150 miles of perennial streams within the Guest River Watershed and another 145 miles of intermittent streams. Excessive streambank erosion was identified along 10% of perennial streams, or 82,000 feet (Table 15). The greatest percentage of eroding stream bank is in the lower Bear Creek subwatershed, with over 70% of the bank stream length identified as eroding. Upper Bear Creek, Guest River G, and Guest River H were identified as having over 20% eroding.

The riparian buffer was classified as either adequate, marginal, or inadequate with regard to the ability of the riparian buffer to remove pollutants from rainfall runoff before it enters the adjacent stream. Table 16 shows the length of each riparian buffer class by tributary watersheds. The riparian buffer on both sides of the stream was assessed by the photo interpreter.

Throughout the Guest Watershed, about 60% of the riparian buffer was judged to be adequate, 10% was judged inadequate, and the balance was judged marginal. On a subwatershed basis, percent of adequate buffer correlates well with percent of forest land. The highest percentages of inadequate buffer are found in lower Bear Creek, Little Toms Creek, Yellow Creek, and Guest River H.

Table 4. Riparian buffer classification

Woody Vegetation			
Width/Cover	**0 to 33 percent**	**34 to 66%**	**67 to 100%**
0 to 25 feet	Inadequate	Marginal	Marginal
26 to 100 feet	Marginal	Marginal	Adequate
over 100 feet	Marginal	Adequate	Adequate
Grass Vegetation			
Width/Cover	**Poor Quality**	**Moderate Quality**	**Good Quality**
0 to 25 feet	Inadequate	Marginal	Marginal
26 to 100 feet	Inadequate	Marginal	Adequate
over 100 feet	Inadequate	Adequate	Adequate

Road Conditions Methods

Base information for road coverage was the road network on the standard 1:24,000 USGS topographic maps. The road network was updated to the date of the photography (March 28, 2001). Road conditions interpreted for the NPS inventory were the surface type and the significant erosion features associated with the road. Road surfaces were identified as either paved (impervious) or unpaved. Unpaved roads included all classes of unpaved surface from well-maintained gravel to off-road vehicle trails. The significant erosion features associated with the road included eroding cuts and fills, eroding banks along the road, and eroding ditches along the road.

Table 5. Drainage features mapped for the Guest River Watershed

Feature	Description
Perennial Stream	Water is present throughout most years. Stream usually has a base flow.
Intermittent Stream	Water is not present at all times. Stream does not have a base flow throughout most years. The stream has a well-defined channel.
Ephemeral Stream	Drainage ways which flow during an individual storm event. There is not a well-defined channel.
Channelized Stream	Perennial or intermittent stream altered by straightening or dredging.
Eroded Streambank	Stream segments that are eroding with visible collapsed banks.
Grassed Waterway	Stream channel that has been planted in vegetation as an erosion control measure or practice.
Animal Access	Stream segments where livestock have direct, constant access. Animals are not restricted from the stream by natural or artificial constraints, and there is evidence that animals are entering the stream. Such segments may be small sites where the animals drink or longer segments such as streams through confined feedlots.
Probable Animal Access	Stream segments through areas where there is direct evidence of presence of animals, and there is no physical barrier to the stream. Barriers could be fences or high banks. Livestock have access to the entire segment but, in most instances, are using isolated access points for entry to the stream.
Potential Animal Access	Stream segment through areas that exhibit no direct evidence of current animal activity. An example is a hay field that may be used in a pasture rotation. The stream has no physical barrier to livestock.

Road Conditions summary

Characteristics of roads are shown in Table 17. There is a total of approximately 886 miles of road within the Guest River Watershed: 537 unpaved miles, 315 paved miles, and 34 miles of road within active mine areas. Over a third (36%) of the unpaved road was identified as associated with an eroding bank, road cut, or ditch; only 1.8% of paved roads were associated with similar erosive features.

On-Site Septic Systems Methods

Stressed on-site septic systems can contribute contaminants to the surface water through overland flow, particularly when saturated soil conditions exist. The intent of the NPS inventory was to identify signatures on the aerial photography which are associated with on-site systems and may indicate the conditions of a stressed or potentially stressed system. The four conditions identified are listed in Table 6. Locations of sewered areas were provided by the Wise County Health Department. Information on on-site septic systems was not used in the loading model

Suspect On-Site Septic Systems Summary

The remote sensing process identified 602 sites within the Guest River Watershed with on-site septic systems that may be contributing contaminants to the surface water through overland flow, particularly when saturated soil conditions exist. These systems are identified as suspect and field investigations should be conducted before concluding all systems are failing. A breakdown by watershed and reason for suspicion are given in Table 18 for residences (including mobile homes) and commercial sites. The location of these sites is shown in Figure 6. Almost all (99%) of the suspect sites serve residences.

Of the total suspect house sites, 26% exhibited a visible plume pattern, but no drain field was apparent. This may indicate a straight-pipe from a septic system, roof drainage, gray water disposal or natural seepage/spring. Another 66% showed no visible plume or drain field but were at locations that are questionable for on-site septic systems. Such locations include home sites on very steep slopes, small lots, visible rock outcrops, or close proximity to streams, especially those on heavily-wooded lots. Five percent exhibited an effluent plume from a visible drain field pattern or prominent ponding down slope from the drain field. Sixteen other sites (2.7%) exhibited a visible drain field pattern, but no plume was evident. This may indicate slow leaching, with no apparent breakout from a seasonally- or hydraulically-stressed system. It could also indicate evapotranspiration characteristics of a functioning system or newly-installed system.

Table 6. On-site septic system feature mapped for the Guest River Watershed

Feature Observed	Description/Implication
Distinctive moisture pattern	Effluent plume from visible drain field pattern or prominent ponding down slope from the drain field.
Suspicious moisture pattern	Visible plume pattern, but no drain field apparent; can be straight-pipe from septic system, roof drainage, gray water disposal or natural seepage/spring.
Distinctive drain field	Visible drain field pattern, but no plume evident; may indicate slow leaching, but no apparent breakout of a seasonally- or hydraulically-stressed system, or evapotranspiration characteristics of a functioning system or newly-installed system.
Suspect location	No plume or drain field visible; home sites on very steep slopes, small lots, visible rock outcrops, or in close proximity to streams or reservoirs, especially those on heavily-wooded lots.

Subsidence Features

The NPS inventory identifies subsidence features. Subsidence features may be well-defined sinkholes or subtle features only a few feet or inches in depth. These subtle features are photo-identifiable due to soil moisture characteristics or vegetation changes. These results are shown in the GIS database and are not tabulated.

Impervious Cover Methods

Imperviousness is defined as the percent of the total area of the mapped unit that is covered by impervious surface. A percent imperviousness, excluding paved roads, was assigned to each land use/land cover polygon based on interpretation of the photography. For example, a low-density residential area might be 5% impervious based on the estimated coverage of structures, driveways, and sidewalks. The percent of area covered by paved roads was calculated from the roads' coverage layer in the database. The percent imperviousness for each watershed was then calculated by summing the percent imperviousness for each polygon and the roads within the watershed.

Imperviousness Summary

Impervious cover consists of areas or surfaces that prevent precipitation from entering the soil, but instead force precipitation to immediately run off. Impervious cover consists of such things as roofs and paved road and parking lot surfaces. As the amount of imperviousness within a watershed increases, two things happen that impact the water resource. First, the flow characteristics within the streams that drain the watershed change because less soil is available as a water storage reservoir. These flow changes include quicker response to precipitation and increased amounts of water the stream must carry during rain events (higher peak flows), increased flooding frequencies, and lower base (dry weather) flows. As peak stream flows increase, the stream channel becomes deeper and/or wider in an effort to carry the increased flow. This results in increased sediment loads and loss of aquatic and riparian habitat as soil and vegetation are scoured from the bottom and banks cave into the stream. Second, the amount of pollutants delivered to the stream is increased through runoff from these impervious surfaces and fewer opportunities for filter in the soil. Impervious surfaces collect and accumulate pollutants deposited from the atmosphere, leaked from cars, or derived from other activities. Pollutants can include nitrogen, phosphorus, bacteria, metals, and oils. In addition, thermal pollution (higher water temperatures than the biological community is adapted to) and/or thermal shock (abrupt changes in water temperature) can occur when precipitation runs off of impervious surfaces warmed by the sun.

Research shows that it is extremely difficult to maintain predevelopment stream quality when watershed development exceeds 10 to 20 percent impervious cover. In general, as the imperviousness increases beyond 10 to 20 percent, the stream becomes impacted. Fish and aquatic insect species (food for many fish, amphibians, and birds) are lost as stream temperatures increase, and stream channels become unstable. In many watersheds above 25 percent imperviousness, most, if not all, fish are gone; stream channels are very unstable; and pollutant loads have increased to levels that threaten downstream lakes. Establishing an exact impervious threshold for protecting a given stream is not possible. However, the following thresholds are proposed for three levels of stream protection (Schueler, 1994): Stressed streams (1 to 10 percent impervious cover); impacted streams (11 to 25 percent impervious cover); and degraded streams (26 to 100 percent impervious cover)

For stressed streams, predevelopment stream quality can be maintained if strict zoning, site impervious restrictions, stream buffers, and best management practices are applied. Impacted streams can be expected to experience some degradation after development even with controls. For degraded streams, predevelopment stream quality cannot be fully maintained even when controls and retrofits are applied. Intensive stream restoration techniques, if applied, can only partially restore some aspects of stream quality.

The percent imperviousness for each watershed and selected land use/land cover classes are shown in Table 19 andTable 20. The percent of imperviousness for the Guest River Watershed is 4.1%, which is below the impact threshold. Five subwatersheds are in Schueler's "stressed" category, with imperviousness between 10% and 25%. These are lower Toms Creek and Guest River F, both above 20% imperviousness; and Guest River G, Yellow Creek, and Guest River C, all around 13% imperviousness. Except for Yellow Creek, these are not complete watersheds, so the influence of these drainage areas on the nature of the stream will be diluted by upstream conditions. Limited monitoring data indicates that the biological conditions in Yellow Creek are better than at other sites in the Guest Watershed (although still rated only Fair by the TVA criteria) in spite of a relatively high imperviousness (13.3%).

Pollutant Loading Model

A model was developed to estimate nonpoint source pollutant loads based on the NPS inventory. The model can be used to estimate pollutant loads for TSS, five-day biochemical oxygen demand, TN, and TP, or other conservative pollutants from a variety of land uses. The model uses a Microsoft Excel for Windows 2002 workbook to perform the calculations and display the results in tabular and graphical form. The workbook consists of sheets for the land use inventory, USLE factors, other loading parameters, and a calculation sheet for each loading parameter, accompanied by graphs to display results. These parameters were developed as discussed in the Methods section of this report. Treatment scenarios can be explored by changing model parameters in a copy of the original model and viewing the changes in the linked graphs and tables.

Not all of the data described in the Methods and Summary section were used in the model. Both the onsite waste system information and the riparian buffer information were intended to support management activities, but were not used in the loading model.

Pollutant Loads from Urban Land Classes

The pollutant load from the urban land uses within the Guest River Watershed was estimated using a method described by the U.S. Environmental Protection Agency (USEPA, 1990). This USEPA method uses the following equation:

$$M = RainV \times Rv \times Area \times Conc \times 0.0001135 \qquad \text{Equation (1)}$$

Where:

M	=	mass load (tons)
RainV	=	rainfall amount (inches)
Rv	=	runoff coefficient (unitless)
Area	=	drainage area (acres)
Conc	=	average concentration in runoff (mg/L)
0.0001135	=	unit conversion factor

This equation was used to estimate the annual pollutant load for the following land classes: residential, commercial, industrial, and transportation. The areas used for each land class were generated by the nonpoint source inventory.

The values shown in Table 7 were used in the model. These values were taken from the literature (Schueler, 1994), and were then modified as calibration parameters.

Average annual rainfall for the watershed was estimated at 47 inches from the U.S. Department of Agriculture, Natural Resources Conservation Service, National Water and Climate Center at www.ocs.orst.edu/pub/maps/Precipitation/Total/States/VA/va.gif.

Runoff coefficients for the different land classes were estimated using the following equation taken from the USEPA report, "Urban Targeting and BMP Selection" (USEPA, 1990):

$$Rv = 0.050 + 0.009\ (PI) \qquad \text{Equation (2)}$$

Where:

PI is percent imperviousness estimated from the remote sensing process

The values used for PI by land use/land cover class were determined by remote sensing.

Table 7. Parameter values used to estimate pollutant loads from urban land use classes

Land Class		**Residential**	**Commercial**	**Developed open**	**Industrial**	**Transportation**	**Major Highway**
Annual Rainfall	inches/year	47	47	47	47	47	47
Runoff Coefficient (calculated in eqn. 2)	Unitless	0.23	0.64	0.20	0.51	0.05	0.79
TSS Concentration	mg/L	400	200	50	600	100	100
TN Concentration	mg/L	1.8	1.8	1.8	1.8	1.8	1.8
TP Concentration	mg/L	1.0	0.5	0.75	0.75	0.4	0.4

Pollutant Loads from Crop, Pasture, Forest, Mining, and Disturbed Lands

The first step in estimating pollutant loads from pasture, crop, forest, mining and disturbed lands was determining the soil loss for each class using the USLE:

$$A = R \times K \times LS \times C \times P \qquad \text{Equation (3)}$$

Where:

A = soil loss (tons/acre/year)
R = rainfall energy factor
K = soil erodibility factor (characteristic of a particular soil type)
LS = slope-length factor (calculated from degree of slope and length of slope)
C = cropping management factor (accounts for soil cover, tillage practices, and other management practices that influence soil condition and vulnerability to erosion)
P = erosion control practice factor (generally accounts for management practices that prevent eroded soil from leaving the site)

Table 8. USLE and soil loss factors for the Guest River Watershed

	LU Class	R	K	Slope (%)	Slope length	LS (calculated)	C	P
Row crop, no residue	2101	150	0.28	10	125	1.5	0.155	1
Row crop with residue	2104	150	0.28	10	125	1.5	0.077	1
Fair pasture	213	150	0.28	25	150	7.1	0.014	1
Heavily overgrazed pasture	215	150	0.28	25	150	7.1	0.024	1
Orchard, vineyard, nursery	22	150	0.28	15	150	3.0	0.008	1
Scrub/shrub	32	150	0.28	40	150	16.5	0.015	1
Forest	4	150	0.28	40	150	16.5	0.003	1
Harvested forest	45	150	0.28	40	150	16.5	0.005	1
open water	5	150	0			0.0		1
Active strip mine	7501	150	0.32	35	160	13.3	1	0.00023
Strip mine active: tipple area[1]	750102	150	0.17	55	150	29.9	1	0.00023
Strip mine active: flooded area	750105	150	0			0.0		
Strip mine active: valley fill area	750108	150	0.32	10	300	2.1	0.015	0.00023
Reclaimed strip mine	7502	150	0.32	35	160	13.3	0.013	1
Abandoned strip mine with high wall	75021	150	0.32	35	160	13.3	0.013	1
Highwall slide area	750216	150	0.17	55	160	30.7	0.013	1
Reclaimed strip mine	75022	150	0.32	35	150	23.9	0.013	1
Strip mine reclaimed: slide area	750226	150	0.17	55	160	30.7	0.015	1
Strip mine - abandoned other	7503	150	0.32	35	160	13.3	0.015	1
Borrow area - active	7531	150	0.32	30	100	8.3	0.015	1
Disturbed area	76	150	0.32	25	150	7.1	1	1
Road bank/ditch	5	ft wide	40	t/ac/yr				
Haul roads	20	ft wide	100	t/ac/yr				0.00023
other roads	12	ft wide	5	t/ac/yr				
Stream bank (all)	3.5	ft deep	0.026	tons/linear foot/year				
Abandoned mine features[2]	2	acres	125	tons/year/feature				

[1] P value for Sepulcher Creek tipples = 0.35
[2] Location of abandoned mine features provided by DMME

The USLE data and erosion rates used for the Guest River Watershed were established through consultation with the Natural Resources Conservation Service (NRCS) district conservationist for the area, Glenn Graham, with help from Richard Davis and Joey

O'Quinn of the Virginia Department of Mines Minerals and Energy. The P factor from active mines was calculated from the permitted discharge concentration of sediment (35 mg/l). Tipples were initially treated as active mine areas, but it was discovered that tipple sites that are separate from the mines are not permitted on the same basis as the mines. This led to a change in the P value for tipples in the Sepulcher Creek watershed. The USLE factors and soil erosion rates for linear features are listed in Table 8.

The pollutant load from these lands within the Guest River Watershed was estimated using the soil loss values calculated from Equation (3) and the following equation:

$$M = A \times Area \times DR \times PC \qquad \text{Equation (4)}$$

Where:

M	=	pollutant loading (tons/ year)
A	=	soil loss (tons/acre/year, from Equation 3)
Area	=	land class area (acre)
DR	=	sediment delivery ratio (unitless)
PC	=	pollutant coefficient (ton pollutant/ton soil)

The acreage used for the various land classes were determined by the nonpoint source inventory.

The sediment delivery ratio was estimated from the United States Department of Agriculture, National Engineering Handbook, Section 3 - Sedimentation, Chapter 6 - Sediment Sources, Yields and Delivery Ratios, Figure 6-2 (USDA, 1978).

Figure 6.2 is based on the following equation:

$$DR = 0.417762*(A^{-0.134958}) - 0.127097 \qquad \text{Equation (5)}$$

Where:

DR	=	Watershed delivery Ratio (unitless)
A	=	Watershed area (sq. miles)

The following pollutant coefficients were used in the model for the Guest River Watershed :

Total Nitrogen 0.002 tons pollutant/ton soil for most land uses, and 0.004 tons for agricultural land uses
Phosphorus 0.0002 tons pollutant/ton soil
Total Suspended Solids 0.4 tons pollutant/ton soil

Nutrient characteristics were initially based on Mills et. al (1985). Total suspended solids (TSS) were estimated to be 40% of the eroded soil that reaches the stream. These levels were used as calibration parameters.

The soil loss from unpaved roads was calculated by estimating an average erosion rate and assuming an average width. For eroding stream banks, a regression rate (in inches per year), an average bank height, and an average soil density were estimated. When multiplied together, these provide a soil loss rate per linear foot. This approach was also used on eroding road banks. Locations of abandoned mine features (such as high-erosion areas) were provided by DMME (Figure 7). These were assumed to average 2 acres in extent and generate soil loss at an average rate of 125 tons/year. Soil loss from these linear or point features used in Equations 4 and 5 to determine pollutant loading from these sources.

Pollutant Loads from Beef Cattle Operations

The pollutant load from the beef cattle operations identified within the Guest River Watershed was estimated using the following equation:

$$M = NA \times WT \times PR \times 0.0001825 \times DR \times NSn \qquad \text{Equation (6)}$$

Where:

M	=	pollutant loading (tons/ year)
NA	=	number of animals (number/site)
WT	=	animal weight (pounds)
PR	=	pollutant production rate (lb pollutant/day/1000 lb live wt)
0.0001825	=	unit conversion factor
DR	=	delivery ratio (unitless)
NSn	=	number of sites of type n

The values used to calculate the pollutant loads for beef cattle are given in Table 9. The numbers of cattle operations within the Guest River Watershed were identified by the nonpoint source inventory. The cattle sites were identified as small, medium, or large and adjacent or nonadjacent to the stream. The (as excreted) pollutant production rates

(PR) for total nitrogen and total phosphorus were obtained from the NRCS Agricultural Waste Management Field Handbook (USDA, 1996). The production rate for TSS was based on values derived from “Livestock Manure Characterization Values from the North Carolina Database” (Barker, et al., 1990). Glenn Graham of the NRCS provided representative herd size estimates for small, medium, and large operations based on his knowledge of the area.

This component of the loading model primarily accounts for the direct deposition of animal waste into streams, and secondarily accounts for the increase in nutrient-rich material on pastures that is available for washoff.

Table 9. Parameter values used to estimate pollutant loads from beef cattle operations

Type of Operation		Units	Beef Cattle
Number of Animals per Site	Large	Number	70
	Medium	Number	20
	Small	Number	10
Animal Weight		lbs/animal	1000
Delivery Ratio - Adjacent Site	TSS	unitless	0.032
	TN	unitless	0.032
	TP	unitless	0.032
Delivery Ratio - Nonadjacent Site	TSS	unitless	0.001
	TN	unitless	0.001
	TP	unitless	0.001
Pollutant Production	TSS	lb/day/1000 lb live wt	3.39
	TN	lb/day/1000 lb live wt	0.31
	TP	lb/day/1000 lb live wt	0.11

Estimating the amount of time cattle spend loafing or drinking in or immediately adjacent to streams provides a basis for estimation of the direct delivery of waste. Discussions with Glenn Graham of NRCS provided the following estimates of time in the creek for cattle with access to streams: 15 minutes per day from November through March; 30 minutes per day in April; one hour per day in May; 1.5 hours per day in June and July; 2 hours per day in August; 1 hour per day in September; and 45 minutes per day in

October. This translates to 3.2% of a year, or 3.2% of cattle waste directly deposited into streams. A factor of 0.1% was used to estimate direct washoff of cattle waste in pastures that are not adjacent to streams

Pollutant Loads from Horse Operations

The pollutant load from the horse operations identified within the Guest River Watershed was estimated using the following equation:

$$M = NA \times WT \times PR \times 0.0001825 \times DR \times NSn \qquad \text{Equation (9)}$$

Where:

M	=	pollutant loading (tons/ year)
NA	=	number of animals (number/site)
WT	=	animal weight (pounds)
PR	=	pollutant production rate (lb pollutant/day/1000 lb live wt)
0.0001825	=	unit conversion factor
DR	=	delivery ratio (unitless)
NSn	=	number of sites of type n

The values used to calculate the pollutant loads for horses are given in Table 10. The numbers of horse sites within the Guest River Watershed were identified by the nonpoint source inventory. The horse sites were identified as small, medium, or large and adjacent or nonadjacent to the stream. Glenn Graham of the NRCS provided representative herd size estimates for small, medium, and large operations based on his knowledge of the area.

The (as excreted) pollutant production rates (PR) total nitrogen and total phosphorus were obtained from the NRCS Agricultural Waste Management Field Handbook (USDA, 1996). The production rate for TSS was based on values derived from “Livestock Manure Characterization Values from the North Carolina Database” (Barker, et al., 1990).

The process used to estimate delivery of horse waste was similar to that used for cattle. According to Mr. Graham (and other observers), horses spend only long enough in the stream to drink, and their time in the stream does not change seasonally. Time in the stream for horses is estimated at 15 minutes per day, or 1% of time on an annual basis.

A 0.1% factor was used for washoff from operations that are not adjacent to a stream, as in the case of cattle.

Table 10. Parameter values used to estimate pollutant loads from horse operations

Type of Operation		Units	Horse
Number of Animals per Site	Large	Number	10
	Medium	Number	3
	Small	Number	1
Animal Weight		lbs/animal	1000
Delivery Ratio - Adjacent to Stream	TSS	unitless	0.01
	TN	unitless	0.01
	TP	unitless	0.01
Delivery Ratio - Nonadjacent to Stream	TSS	unitless	0.001
	TN	unitless	0.001
	TP	unitless	0.001
Pollutant Production	TSS	lb/day/1000 lb live wt	6.2
	TN	lb/day/1000 lb live wt	0.31
	TP	lb/day/1000 lb live wt	0.16

Nonpoint Source Inventory Summary Tables and Figures

Table 11. General land use/land cover for the Guest River Watershed by subwatershed, percent

Watershed Name	Watershed ID	Residential	Commercial	Industrial	Transportation, communication, utility	Railroad	Row crop	Pasture	Forest, scrub, orchard	Open Water	Active strip mine	Reclaimed strip mine	Abandoned strip mine	Borrow, disturbed	Wetland
Guest River A	01	3.9%	0.4%	0.0%	0.3%	0.0%	0.0%	5.1%	80.4%	1.0%	0.0%	0.0%	8.8%	0.1%	0.0%
Crab Orchard Br.	0201, 0202	16.6	0.0	0.0	0.6	0.0	0.00	6.2	72.3	0.1	0.0	0.2	3.3	0.2	0.4
Guest River B	02, 03	8.9	0.7	0.0	1.0	0.0	0.05	4.7	83.1	1.3	0.0	0.0	0.2	0.0	0.0
Pine Camp Cr.	0401, 0402	6.8	0.1	0.0	0.1	0.0	0.02	8.4	84.3	0.2	0.0	0.0	0.0	0.0	0.0
Guest River C	04, 05	48.0	4.5	0.0	0.0	0.0	0.00	10.5	33.0	4.0	0.0	0.0	0.0	0.0	0.0
lower Toms Creek	0601	46.4	7.4	0.0	10.5	0.0	0.00	3.2	30.4	0.7	0.0	0.0	1.3	0.0	0.0
Little Toms Cr.	060201, 060202	12.8	2.1	0.0	4.7	0.0	0.00	3.0	64.1	0.1	0.0	0.0	13.2	0.0	0.0
upper Toms Creek	0602, 0603, 0604	8.3	2.2	0.1	0.5	0.0	0.00	8.3	59.4	0.3	6.7	0.4	12.8	0.0	0.9
Guest River D	06, 07, 08, 09	9.4	2.2	0.5	1.6	0.0	0.06	8.2	71.1	0.8	0.3	0.0	5.5	0.2	0.0
Burns Cr.	1001, 1002	1.7	0.0	0.0	0.3	0.0	0.00	0.7	97.3	0.0	0.0	0.0	0.1	0.0	0.0
Guest River E	10, 11	1.9	1.0	0.4	1.8	0.2	0.00	2.6	87.4	1.1	3.0	0.0	0.6	0.0	0.0
Guest River F	12	9.3	21.2	0.9	5.4	0.0	0.00	0.0	8.6	0.1	1.8	48.8	3.8	0.0	0.0
lower Bear Cr.	1201, 1202	7.8	0.5	3.3	6.0	0.0	0.00	2.7	55.4	0.1	0.0	0.1	24.1	0.0	0.0
Yellow Cr.	120301, 120302	33.8	10.6	0.7	0.5	0.0	0.00	9.2	31.3	0.5	0.0	2.8	10.5	0.0	0.0
upper Bear Cr.	1203, 1204	13.9	3.9	0.6	4.2	0.0	0.00	10.4	37.3	1.3	3.3	13.1	11.0	0.0	0.8
Clear Cr.	1301, 1302	1.3	0.0	0.0	0.2	0.0	0.00	0.0	98.4	0.0	0.0	0.0	0.0	0.0	0.0
Guest River G	13, 14	15.6	8.9	3.4	3.5	0.9	0.12	1.8	52.9	0.1	1.8	3.7	6.6	0.1	0.4
Sepulcher Cr.	1501, 1502	7.3	0.6	1.2	0.9	0.0	0.00	3.1	60.9	0.6	2.3	7.4	12.2	0.2	3.3
Guest River H	15, 16, 17	11.7	0.1	0.1	1.4	0.0	0.00	3.8	58.1	0.2	0.0	12.7	11.0	0.0	0.8
Guest River I	18	0.1	0.0	0.0	0.5	0.0	0.00	2.2	36.8	0.9	20.5	30.7	5.7	0.7	2.0
Guest River Watershed Total		**9.6%**	**2.3%**	**0.54%**	**1.6%**	**0.08%**	**0.02%**	**5.0%**	**63.6%**	**0.60%**	**3.1%**	**5.3%**	**7.6%**	**0.12%**	**0.70%**

Table 12. General land use/land cover for the Guest River Watershed by subwatershed, in acres

Watershed Name	Watershed ID	Total Area	Residential	Com-mercial	Indus-trial	Trans-portation, communi-cation, utility	Railroad	Row crop	Pasture	Forest, scrub, orchard	Active strip mine	Reclaimed strip mine	Abandoned strip mine	Borrow, disturbed	open water	wetland
Guest River A	01	4544.9	178.8	16.9	0.0	14.2	0.0	0.0	230.6	3654.9	0.0	0.0	402.0	3.0	44.4	0.1
Crab Orchard Br.	0201, 0202	1714.9	284.9	0.7	0.0	10.5	0.0	0.0	106.5	1240.3	0.0	3.6	56.8	3.7	1.7	6.2
Guest River B	02, 03	3626.4	323.5	23.9	0.0	35.8	0.0	1.9	171.8	3015.5	0.0	0.0	7.8	0.6	45.6	0
Pine Camp Cr.	0401, 0402	1689.3	114.8	1.9	0.0	2.3	0.0	0.4	141.8	1423.7	0.0	0.0	0.5	0.0	3.9	0
Guest River C	04, 05	151.8	72.9	6.9	0.0	0.0	0.0	0.0	15.9	50.1	0.0	0.0	0.0	0.0	6.0	0
lower Toms Creek	0601	270.0	125.3	20.0	0.0	28.3	0.0	0.0	8.7	82.1	0.0	0.0	3.6	0.0	2.0	0
Little Toms Cr.	060201, 060202	3516.2	451.2	72.2	0.8	164.3	0.0	0.0	104.6	2254.1	0.0	0.0	465.4	0.0	3.6	0
upper Toms Creek	0602, 0603, 0604	6764.9	560.1	151.6	4.0	31.7	0.0	0.0	562.7	4015.4	456.6	25.1	868.4	3.1	23.1	63.1
Guest River D	06, 07, 08, 09	5500.3	516.3	122.2	25.7	88.4	0.0	3.2	451.0	3912.0	18.7	0.0	301.6	12.6	45.9	2.7
Burns Cr.	1001, 1002	1823.9	30.5	0.0	0.0	5.0	0.0	0.0	13.1	1773.7	0.0	0.0	1.0	0.0	0.6	0
Guest River E	10, 11	3359.7	63.9	34.5	11.8	59.6	7.6	0.0	87.0	2936.0	99.5	0.0	21.8	0.0	38.0	0
Guest River F	12	180.3	16.7	38.2	1.7	9.8	0.0	0.0	0.0	15.6	3.3	88.0	6.8	0.0	0.2	0
lower Bear Cr.	1201, 1202	827.2	64.1	4.2	27.3	49.3	0.0	0.0	22.1	458.5	0.0	0.8	199.5	0.0	1.1	0.3
Yellow Cr.	120301, 120302	3154.3	1067.0	333.0	23.4	15.7	0.0	0.0	291.4	988.5	0.0	87.2	331.3	0.3	16.3	0.2
upper Bear Cr.	1203, 1204	4756.4	663.9	184.4	28.8	199.5	0.0	0.0	496.0	1774.4	155.2	625.2	524.0	1.1	63.6	40.3
Clear Cr.	1301, 1302	3473.2	46.4	0.3	0.0	8.2	0.0	0.0	1.1	3416.6	0.0	0.0	0.5	0.0	0.1	0
Guest River G	13, 14	4597.5	716.4	408.3	154.2	162.5	42.5	5.5	84.0	2433.2	84.5	172.1	305.2	4.4	5.1	19.6
Sepulcher Cr.	1501, 1502	5623.4	411.0	34.6	65.5	49.5	0.0	0.0	173.8	3422.3	128.8	418.7	687.5	10.4	33.0	188.3
Guest River H	15, 16, 17	3661.3	429.2	4.1	4.0	50.7	0.0	0.0	140.0	2129.1	0.0	466.6	402.4	1.4	5.7	28.1
Guest River I	18	5001.6	2.7	0.0	0.0	22.9	0.0	0.0	112.2	1842.9	1023.9	1536.2	282.7	35.2	44.1	98.8
	Total	64237.5	6139.6	1457.9	347.2	1008.2	50.1	11.0	3214.3	40838.9	1970.5	3423.5	4868.8	75.8	384.0	447.7

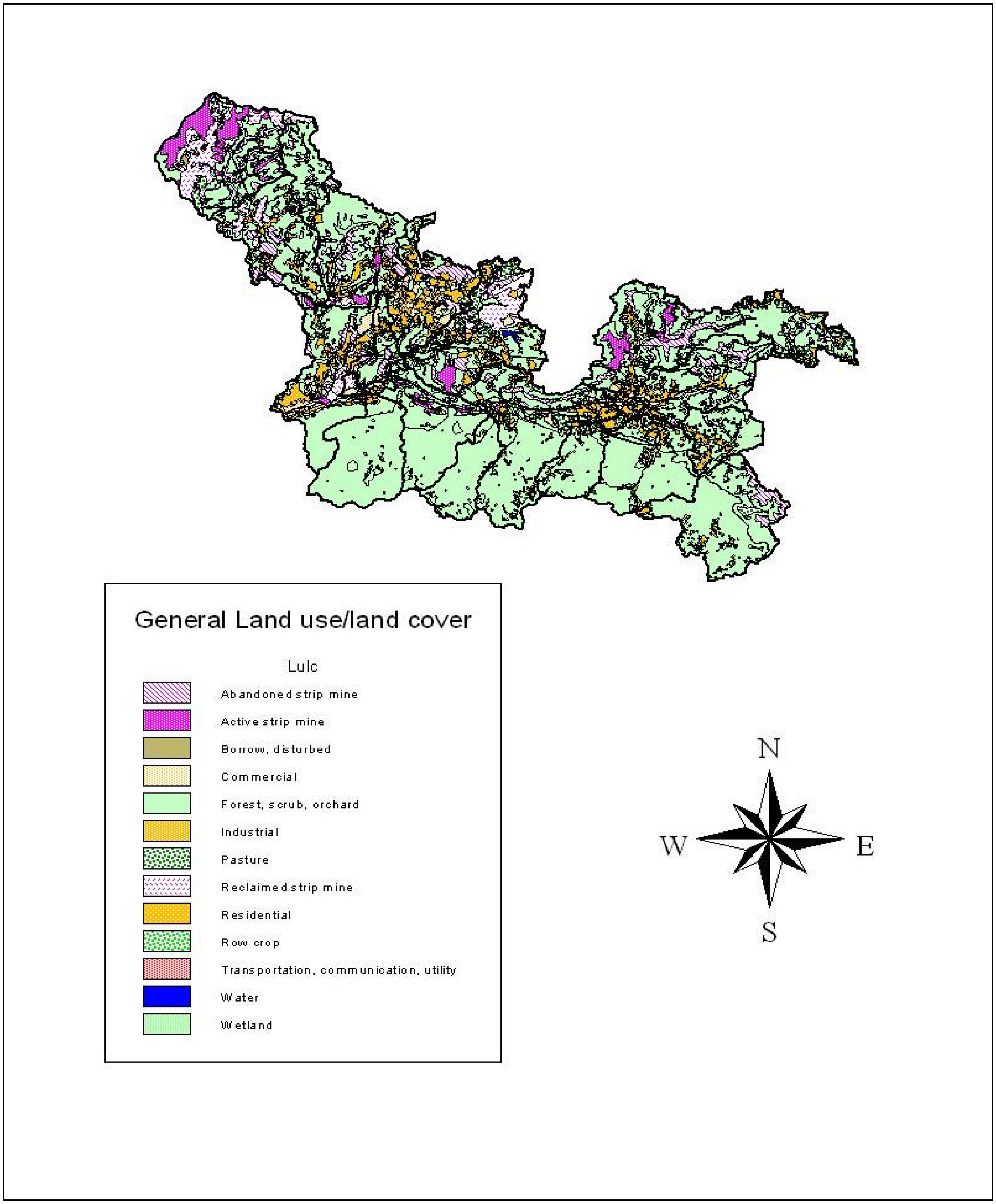


Figure 3. General land use/land cover for the Guest River Watershed

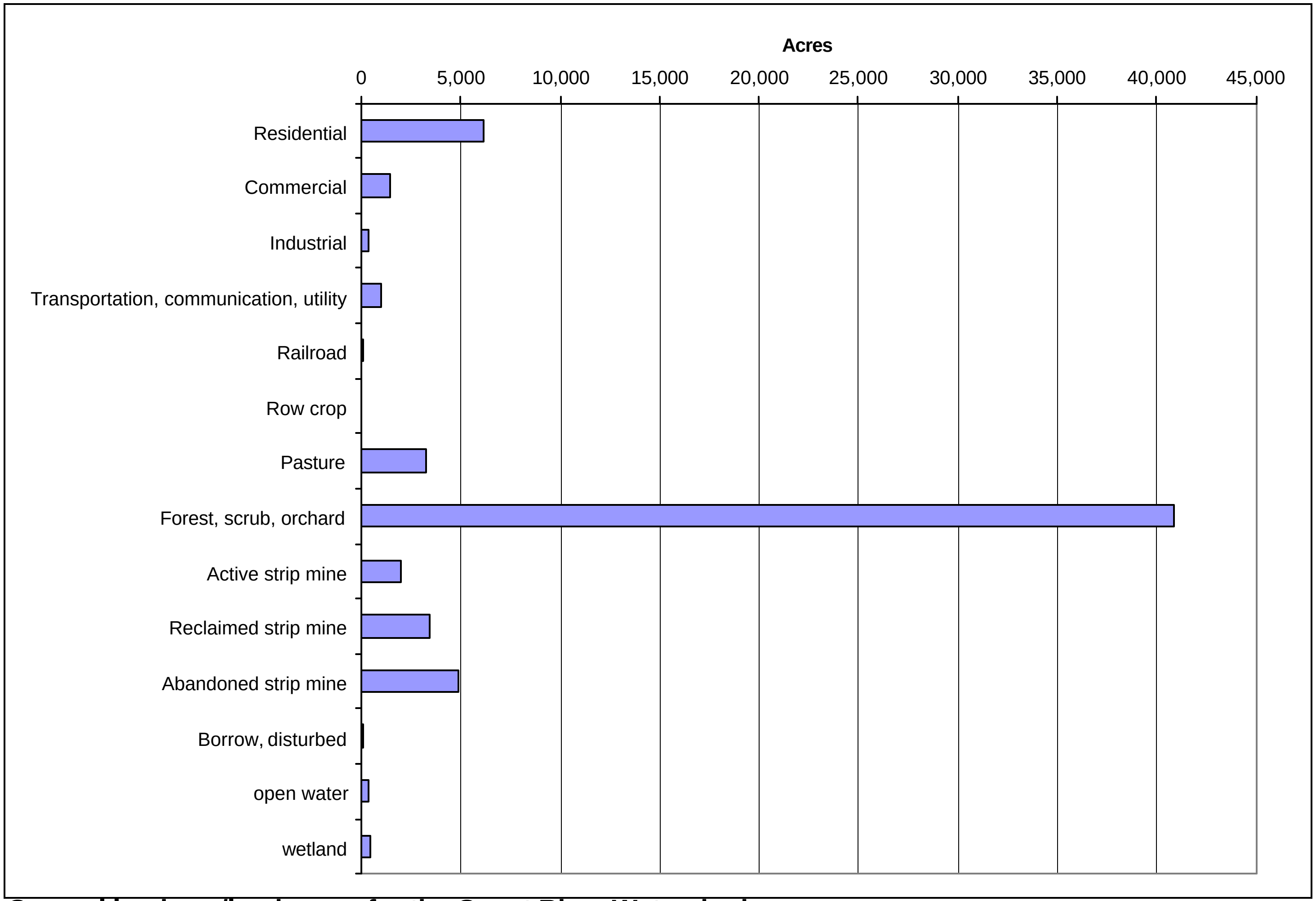


Figure 4. General land use/land cover for the Guest River Watershed

Table 13. Number and type of beef cattle sites in the Guest River Watershed

			Number of sites							
			Adjacent to Stream				Non-adjacent to Stream			
Subwatershed Name	Subwatershed ID	Total	Large	Medium	Small	Subtotal	Large	Medium	Small	Subtotal
Guest River A	01	7	0	2	1	3	0	0	4	4
Crab Orchard Br.	0201, 0202	3	0	0	2	2	0	0	1	1
Guest River B	02, 03	2	0	0	0	0	0	0	2	2
Pine Camp Cr.	0401, 0402	3	0	0	0	0	0	0	3	3
Guest River C	04, 05	0	0	0	0	0	0	0	0	0
lower Toms Creek	0601	0	0	0	0	0	0	0	0	0
Little Toms Cr.	060201, 060202	5	0	0	3	3	0	0	2	2
upper Toms Creek	0602, 0603, 0604	15	0	1	7	8	0	0	7	7
Guest River D	06, 07, 08, 09	8	0	2	2	4	0	0	4	4
Burns Cr.	1001, 1002	0	0	0	0	0	0	0	0	0
Guest River E	10, 11	2	0	0	0	0	0	0	2	2
Guest River F	12	0	0	0	0	0	0	0	0	0
lower Bear Cr.	1201, 1202	1	0	1	0	1	0	0	0	0
Yellow Cr.	120301, 120302	6	0	1	0	1	0	0	5	5
upper Bear Cr.	1203, 1204	8	0	1	2	3	0	1	4	5
Clear Cr.	1301, 1302	0	0	0	0	0	0	0	0	0
Guest River G	13, 14	2	0	0	2	2	0	0	0	0
Sepulcher Cr.	1501, 1502	5	0	0	3	3	0	0	2	2
Guest River H	15, 16, 17	9	0	0	2	2	0	0	7	7
Guest River I	18	1	0	0	0	0	0	1	0	1
	Total sites	77	0	8	24	32	0	2	43	45

Table 14. Number and type of horse sites in the Guest River Watershed

			Number of sites							
			Adjacent to Stream				Nonadjacent to Stream			
Watershed Name	**Watershed ID**	**Total**	**Large**	**Medium**	**Small**	**Subtotal**	**Large**	**Medium**	**Small**	**Subtotal**
Guest River A	01	0	0	0	0	0	0	0	0	0
Crab Orchard Br.	0201, 0202	1	0	0	0	0	0	0	1	1
Guest River B	02, 03	1	0	1	0	1	0	0	0	0
Pine Camp Cr.	0401, 0402	1	0	0	0	0	0	0	1	1
Guest River C	04, 05	0	0	0	0	0	0	0	0	0
lower Toms Creek	0601	0	0	0	0	0	0	0	0	0
Little Toms Cr.	060201, 060202	0	0	0	0	0	0	0	0	0
upper Toms Creek	0602, 0603, 0604	5	0	0	1	1	0	0	4	4
Guest River D	06, 07, 08, 09	2	0	0	0	0	0	0	2	2
Burns Cr.	1001, 1002	0	0	0	0	0	0	0	0	0
Guest River E	10, 11	0	0	0	0	0	0	0	0	0
Guest River F	12	0	0	0	0	0	0	0	0	0
lower Bear Cr.	1201, 1202	1	0	0	0	0	0	0	1	1
Yellow Cr.	120301, 120302	5	0	0	0	0	0	0	5	5
upper Bear Cr.	1203, 1204	2	0	0	0	0	0	0	2	2
Clear Cr.	1301, 1302	0	0	0	0	0	0	0	0	0
Guest River G	13, 14	0	0	0	0	0	0	0	0	0
Sepulcher Cr.	1501, 1502	1	0	0	0	0	0	0	1	1
Guest River H	15, 16, 17	1	0	0	0	0	0	0	1	1
Guest River I	18	0	0	0	0	0	0	0	0	0
	Total sites	20	0	1	1	2	0	0	18	18

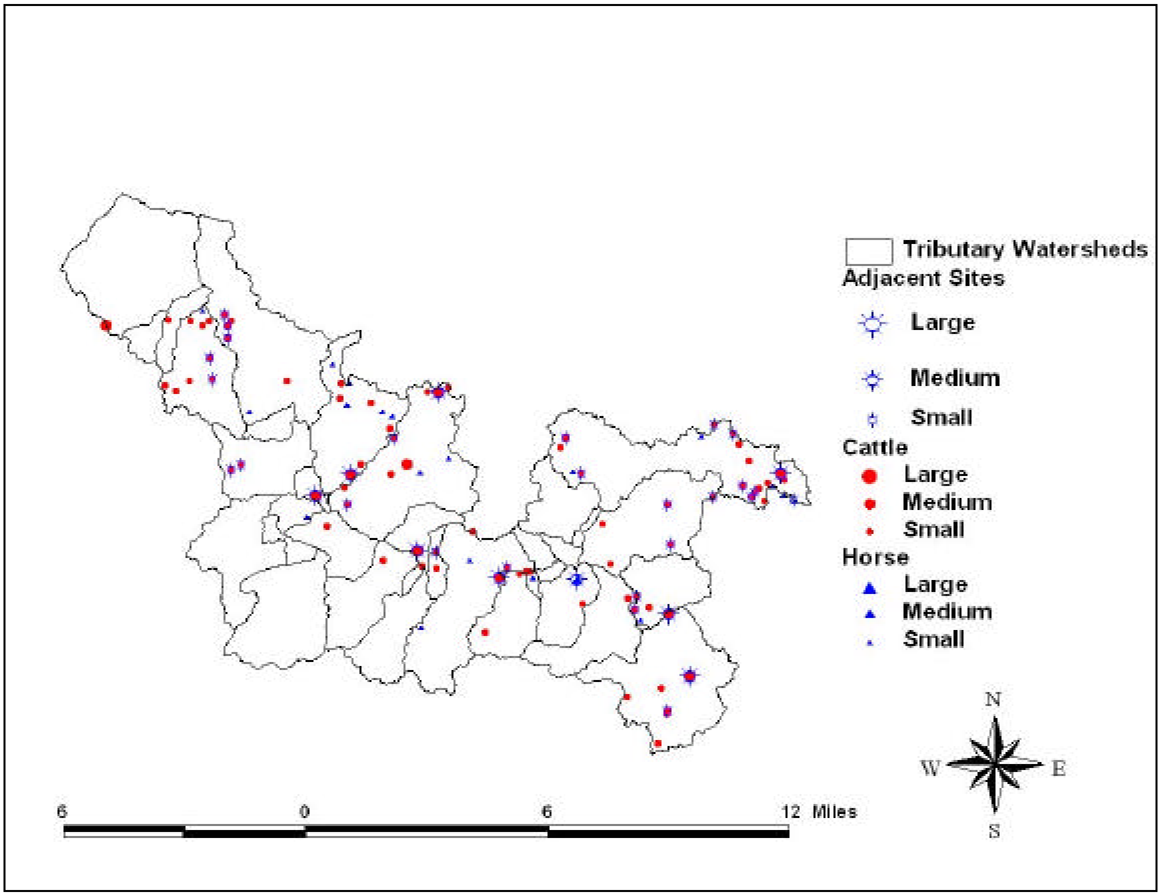


Figure 5. Location of livestock sites within the Guest watershed.

Table 15. Stream types and extent of stream bank erosion in the Guest River Watershed

Subwatershed name	Subwatershed ID	Eroding perennial stream bank, ft	Total perennial stream bank, ft	% eroding perennial stream bank	Eroding intermittent Stream Bank, ft	Total intermittent Stream Bank, ft	% eroding intermittent stream bank
Guest River A	01	828	74517	1.1	2268	55295	4.1
Crab Orchard Br.	0201, 0202	2469	16132	15.3	0	28136	0.0
Guest River B	02, 03	681	68267	1.0	1368	48818	2.8
Pine Camp Cr.	0401, 0402	663	26307	2.5	2084	19405	10.7
Guest River C	04, 05	0	9559	0.0	0	1391	0.0
lower Toms Creek	0601	0	5841	0.0		5148	0.0
Little Toms Cr.	060201, 060202	4454	23205	19.2	6544	75886	8.6
upper Toms Creek	0602, 0603, 0604	4994	69990	7.1	14743	106254	13.9
Guest River D	06, 07, 08, 09	13067	84745	15.4	1572	70020	2.2
Burns Cr.	1001, 1002	17	20026	0.1	0	17436	0.0
Guest River E	10, 11	8768	78654	11.1	0	26346	0.0
Guest River F	12	0	991	0.0		4787	0.0
lower Bear Cr.	1201, 1202	8438	11951	70.6	0	9734	0.0
Yellow Cr.	120301, 120302	1049	26713	3.9	3732	42052	8.9
upper Bear Cr.	1203, 1204	14563	55571	26.2	9967	60396	16.5
Clear Cr.	1301, 1302	138	41405	0.3	0	30188	0.0
Guest River G	13, 14	9313	45971	20.3	3025	51372	5.9
Sepulcher Cr.	1501, 1502	5223	60292	8.7	10584	72044	14.7
Guest River H	15, 16, 17	7579	33046	22.9	5761	47669	12.1
Guest River I	18	0	41167	0.0	17079	61235	27.9
Total		82242	794351	10.4	78726	763593	10.3

Table 16. Riparian buffer conditions in the Guest River Watershed

		Left bank riparian buffer condition						
Subwatershed name	**Subwatershed ID**	Adequate, ft	% Adequate	Marginal, ft	% Marginal	Inadequate, ft	% Indequate	Total, ft
Guest River A	01	47310	90	3228	6	1997	4	52535
Crab Orchard Br.	0201, 0202	8816	55	6338	39	979	6	16132
Guest River B	02, 03	39232	87	4160	9	1880	4	45272
Pine Camp Cr.	0401, 0402	17144	66	5862	22	3122	12	26128
Guest River C	04, 05	3248	68	1529	32	0	0	4778
lower Toms Creek	0601	1634	55	1336	45	0	0	2970
Little Toms Cr.	060201, 060202	3073	13	10023	43	10109	44	23205
upper Toms Creek	0602, 0603, 0604	30357	46	29127	44	6188	9	65671
Guest River D	06, 07, 08, 09	23280	42	24784	45	7206	13	55269
Burns Cr.	1001, 1002	19885	99	107	1	0	0	19992
Guest River E	10, 11	26920	57	15372	32	5138	11	47429
Guest River F	12	288	29	703	71	0	0	991
lower Bear Cr.	1201, 1202	3565	30	3872	32	4515	38	11951
Yellow Cr.	120301, 120302	10839	41	8339	31	7536	28	26713
upper Bear Cr.	1203, 1204	17719	55	12340	38	2325	7	32384
Clear Cr.	1301, 1302	39389	96	1578	4	218	1	41185
Guest River G	13, 14	15925	35	26167	57	3706	8	45798
Sepulcher Cr.	1501, 1502	35722	67	13785	26	3994	7	53502
Guest River H	15, 16, 17	11874	36	19072	58	2099	6	33046
Guest River I	18	10428	45	7350	32	5205	23	22982
Total		366645	58	195071	31	66217	11	627933

		Right bank riparian buffer condition						
Subwatershed name	**Subwatershed ID**	Adequate, ft	% Adequate	Marginal, ft	% Marginal	Inadequate, ft	% Indequate	Total, ft
Guest River A	01	48,665	93	1,840	4	1,902	4	52,407
Crab Orchard Br.	0201, 0202	8,129	51	6,238	39	1,698	11	16,065
Guest River B	02, 03	42,219	93	2,648	6	330	1	45,197
Pine Camp Cr.	0401, 0402	19,030	73	4,129	16	3,017	12	26,176
Guest River C	04, 05	111	2	4,371	91	299	6	4,782
lower Toms Creek	0601	409	14	2,214	74	370	12	2,993
Little Toms Cr.	060201, 060202	4,641	20	10,048	43	8,516	37	23,205
upper Toms Creek	0602, 0603, 0604	33,966	52	26,342	40	5,363	8	65,671
Guest River D	06, 07, 08, 09	37,603	71	12,335	23	3,324	6	53,261
Burns Cr.	1001, 1002	19,008	95	983	5	0	0	19,992
Guest River E	10, 11	30,395	76	9,030	23	448	1	39,873
Guest River F	12	0	0	991	100	0	0	991
lower Bear Cr.	1201, 1202	4,617	39	2,145	18	5,190	43	11,951
Yellow Cr.	120301, 120302	8,538	32	9,573	36	8,602	32	26,713
upper Bear Cr.	1203, 1204	20,637	64	9,296	29	2,450	8	32,384
Clear Cr.	1301, 1302	38,807	94	1,694	4	684	2	41,185
Guest River G	13, 14	18,042	40	24,339	54	3,058	7	45,440
Sepulcher Cr.	1501, 1502	36,071	68	13,350	25	3,839	7	53,260
Guest River H	15, 16, 17	9,230	28	21,958	66	1,858	6	33,046
Guest River I	18	9,181	40	8,091	1,401	5,710	25	22,982
Total		389,300	63	171,616	28	56,658	9	617,574

Table 17. Road erosion characteristics in the Guest River Watershed

Subwatershed name	Subwatershed ID	Paved road with eroding bank, mi	Total paved road, mi	% paved road with eroding bank	Unpaved road with eroding bank, mi	Total unpaved road, mi	% unpaved road with eroding bank	Active mine road with eroding bank, mi	Total active mine road, mi	% mine road with eroding bank	Total Roads, mi
Guest River A	01	0.44	10.2	4.3	7.5	46.98	16	0.00	0.00	0.0	57.2
Crab Orchard Br.	0201, 0202	0.00	6.5	0.0	7.1	15.71	45	0.00	0.00	0.0	22.2
Guest River B	02, 03	0.63	12.9	4.9	2.0	20.41	10	0.00	0.00	0.0	33.3
Pine Camp Cr.	0401, 0402	0.09	6.0	1.5	3.0	12.88	23	0.00	0.00	0.0	18.9
Guest River C	04, 05	0.12	2.1	5.5	0.6	0.77	74	0.00	0.00	0.0	2.9
lower Toms Creek	0601	0.27	8.2	3.3	0.1	1.16	12	0.00	0.00	0.0	9.4
Little Toms Cr.	060201, 060202	0.76	26.0	2.9	12.2	38.65	31	0.00	0.00	0.0	64.6
upper Toms Creek	0602, 0603, 0604	0.18	27.3	0.7	32.4	60.97	53	7.99	8.35	95.8	96.6
Guest River D	06, 07, 08, 09	0.13	32.2	0.4	18.9	50.71	37	0.00	0.00	0.0	82.9
Burns Cr.	1001, 1002	0.00	2.1	0.0	3.9	11.60	34	0.00	0.00	0.0	13.7
Guest River E	10, 11	0.01	7.2	0.1	20.6	33.66	61	0.53	2.16	24.6	43.0
Guest River F	12	0.02	3.8	0.5	0.5	0.55	98	0.00	0.06	0.0	4.4
lower Bear Cr.	1201, 1202	0.09	4.7	2.0	4.3	7.79	55	0.00	0.00	0.0	12.5
Yellow Cr.	120301, 120302	0.95	47.0	2.0	3.4	13.77	25	0.00	0.00	0.0	60.8
upper Bear Cr.	1203, 1204	1.74	23.0	7.6	14.5	32.55	44	2.54	2.71	93.7	58.3
Clear Cr.	1301, 1302	0.00	1.6	0.0	4.0	38.79	10	0.00	0.00	0.0	40.4
Guest River G	13, 14	0.03	57.0	0.1	9.0	26.08	35	1.16	1.22	94.6	84.3
Sepulcher Cr.	1501, 1502	0.16	19.3	0.8	23.2	57.59	40	0.92	1.97	46.8	78.9
Guest River H	15, 16, 17	0.17	13.4	1.2	7.6	29.20	26	0.00	0.00	0.0	42.6
Guest River I	18	0.00	4.6	0.0	20.6	37.01	56	16.95	17.95	94.4	59.6
Total		5.78	315.0	1.8	195.2	536.85	36	30.09	34.41	87.4	886.2

Table 18. Suspect onsite septic systems in the Guest River Watershed

		Residential					Commercial					
Subwatershed name	**Subwatershed ID**	**1**	**2**	**3**	**4**	**Total**	**1**	**2**	**3**	**4**	**Total**	**Total Sites**
Guest River A	01	1	12	1	11	25	0	0	0	0	0	25
Crab Orchard Br.	0201, 0202	10	16	2	8	36	0	0	0	0	0	36
Guest River B	02, 03	4	21	1	4	30	0	0	0	0	0	30
Pine Camp Cr.	0401, 0402	0	4	0	6	10	0	0	0	1	1	11
Guest River C	04, 05	0	2	0	0	2	0	0	0	0	0	2
lower Toms Creek	0601	0	0	0	8	8	0	0	0	0	0	8
Little Toms Cr.	060201, 060202	1	4	1	32	38	0	0	0	0	0	38
upper Toms Creek	0602, 0603, 0604	2	23	3	16	44	0	0	0	2	2	46
Guest River D	06, 07, 08, 09	4	11	3	27	45	0	0	0	0	0	45
Burns Cr.	1001, 1002	0	0	0	0	0	0	0	0	0	0	0
Guest River E	10, 11	0	0	0	1	1	0	0	0	0	0	1
Guest River F	12	0	0	0	0	0	0	0	0	0	0	0
lower Bear Cr.	1201, 1202	0	1	0	0	1	0	0	0	0	0	1
Yellow Cr.	120301, 120302	2	17	0	180	199	0	0	0	1	1	200
upper Bear Cr.	1203, 1204	4	21	1	10	36	0	0	0	0	0	36
Clear Cr.	1301, 1302	0	0	0	1	1	0	0	0	0	0	1
Guest River G	13, 14	0	7	0	39	46	0	0	0	0	0	46
Sepulcher Cr.	1501, 1502	1	8	0	26	35	0	0	0	1	1	36
Guest River H	15, 16, 17	1	10	4	23	38	0	0	0	1	1	39
Guest River I	18	0	0	0	1	1	0	0	0	0	0	1
Total		30	157	16	393	596	0	0	0	6	6	602

1. Distinctive moisture patterns; identifiable plume from visible fieldline pattern or prominent plume or ponding downslope from a structure.
2. Suspicious moisture patterns; visible plume pattern but no fieldlines apparent.
3. Distinctive drainfield, fieldline pattern but no plume evident.
4. Suspect locations; no plume or fieldlines apparent; homes on very steep slopes, small lots, visible rocks outcrops, in close proximity to streams or reservoirs, or heavily wooded lots.

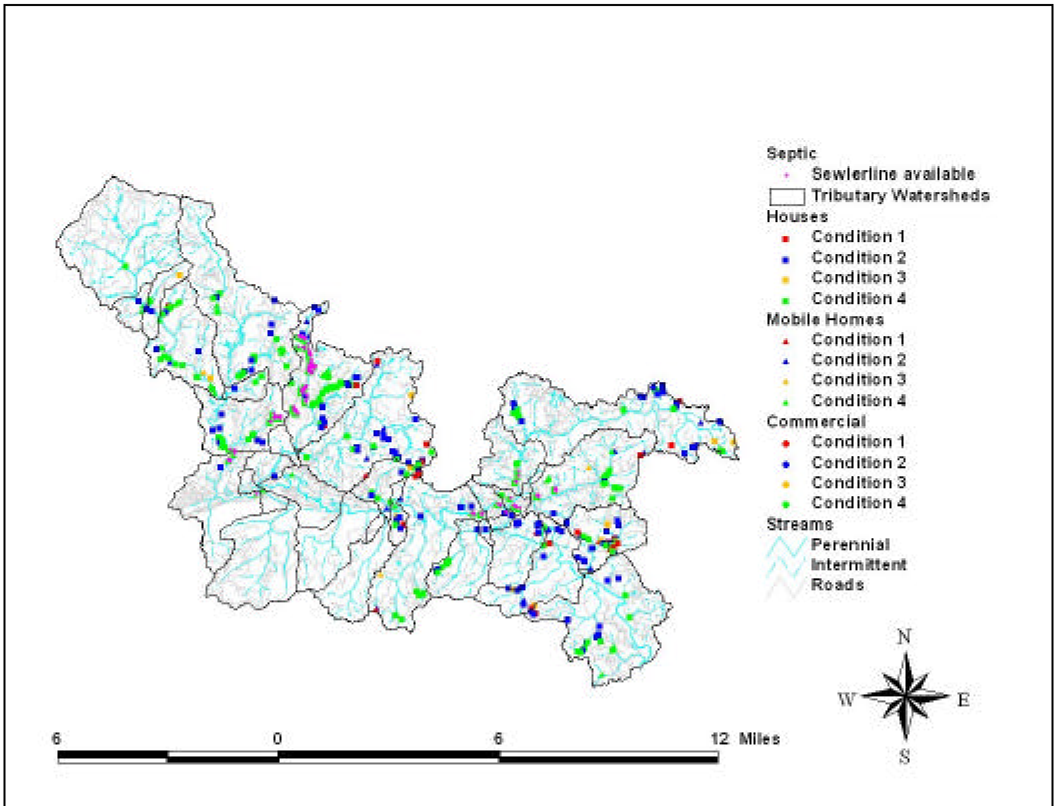


Figure 6. Suspect septic systems in the Guest River Watershed

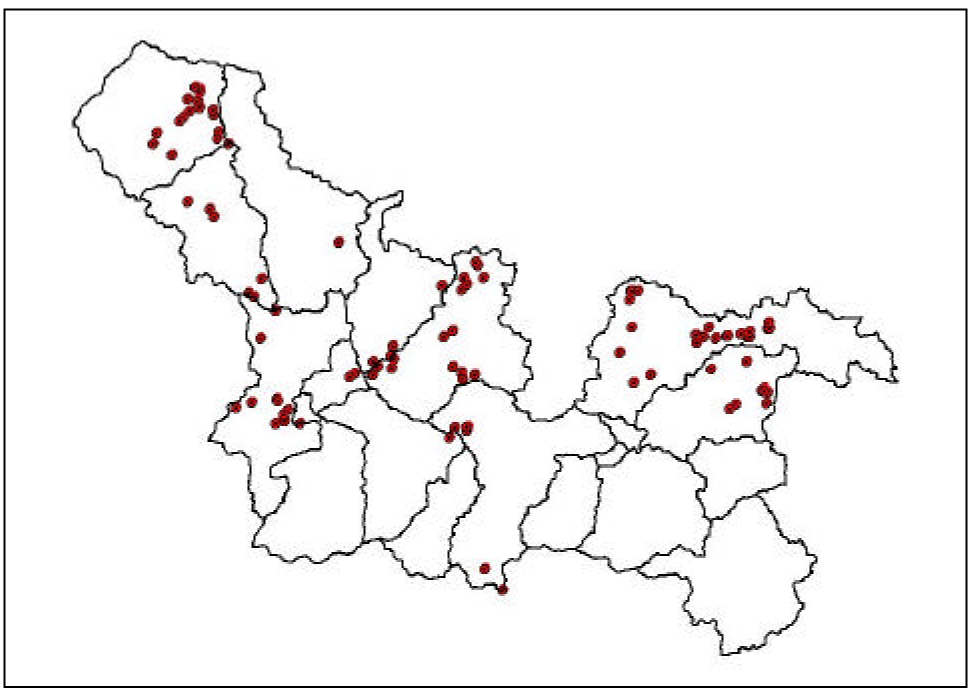


Figure 7. Identified abandoned mine features (from DMME).

Table 19. Total percent imperviousness for subwatersheds in the Guest River Watershed

Watershed Name	Watershed ID	Percent imperviousness
Guest River A	01	1.0
Crab Orchard Br.	0201, 0202	3.3
Guest River B	02, 03	2.3
Pine Camp Cr.	0401, 0402	1.5
Guest River C	04, 05	12.5
lower Toms Creek	0601	22.7
Little Toms Cr.	060201, 060202	6.2
upper Toms Creek	0602, 0603, 0604	2.7
Guest River D	06, 07, 08, 09	4.4
Burns Cr.	1001, 1002	0.5
Guest River E	10, 11	2.0
Guest River F	12	20.8
lower Bear Cr.	1201, 1202	5.5
Yellow Cr.	120301, 120302	13.3
upper Bear Cr.	1203, 1204	5.2
Clear Cr.	1301, 1302	0.3
Guest River G	13, 14	13.3
Sepulcher Cr.	1501, 1502	3.0
Guest River H	15, 16, 17	2.7
Guest River I	18	0.1
Guest River Watershed Total		4.1

Table 20. Imperviousness of urban/built-up land uses in the Guest River Watershed

Land use/Land cover	% Imperviousness
Residential	19.7
Commercial	65.99
Developed Open	16.5
Industrial	50.9
Tranportation, communication, utility	0.11
Airport	0.11
Railroad Yards*	10
Major HWY	82.5
Powerline	0.16
Natural Gas wells*	50

* estimated

Estimated Sediment Load

Nonpoint Source Total Suspended Solids Loading

Pollutant loads were estimated using the land use classes of Table 3, and the loading model described above. Residential and commercial land uses were combined into three categories (residential, commercial, and open developed). Other categories in Table 3 were modeled, along with eroding road banks and unpaved roads, eroding stream banks, and livestock operations (beef cattle and horse). For reporting loads, land use/land cover is combined into residential, commercial, industrial, transportation/communication/utility, cropland, pasture, forest, active strip mine, reclaimed strip mine, abandoned strip mine, borrow and disturbed areas, stream bank, road bank, unpaved road, and livestock. Neither the onsite waste system data nor the riparian buffer data were used in the model. The emphasis of this report is on sediment loads, as represented by total suspended solids, but loads were also estimated for total nitrogen and total phosphorus.

It should be noted that the land use/land cover data used to develop these loading estimates is literally a snapshot. Temporary sources, such as disturbed areas (usually from construction) or forest harvesting, should be compared with other sources with caution. There is no doubt that these changes in the landscape contribute to the nonpoint source pollution load. However, the annual load from these sources is more variable because the sources are not long-term land covers as are the other sources. This variability is not captured by this modeling process.

The estimated annual total suspended solids (TSS) load from selected nonpoint sources to each watershed within the Guest River Watershed is shown in Table 22. The estimated annual TSS load from the Guest River Watershed is about 21,242 tons per year. The contribution of TSS by source for the Guest River Watershed is shown in Figure 8. Because the watershed is predominantly forested, 24% of the sediment is generated by forest land; previously mined land accounts for 34% of the total, and active mines generate 6.4%. Urban land uses generate 22%, and agriculture accounts for 5.7% of the total.

Figure 9 shows the TSS load from each watershed within the Guest River Watershed. The upper Toms Creek, upper Bear Creek, and Guest River G subwatersheds generate the greatest loads, each contributing about 10% of the total. Guest River F and Guest River C contribute sediment at the highest rate on an area basis. The subwatersheds with the largest percent of forest cover (for example Clear Creek and Burns Creek) had the lowest total loads and lowest loading per acre.

Point Source Loading

There are 27 active permitted mine discharges in the Guest River Watershed (Table 23). The sediment discharges from these sites are accounted for in the nonpoint source calculations.

In addition to mine discharges, there are 40 permitted dischargers (Table 24). The Coeburn-Norton-Wise Regional waste water treatment plant is the largest. Loadings from these facilities were estimated using the permit limit of 30 mg/l and the plant's permitted discharge. The sum of the TSS loadings from these facilities is 191 tons of TSS per year, about 1% of the nonpoint source load (Table 21).

Table 21. Comparison of Total Suspended Solids load from Point sources and Nonpoint Sources

Total nonpoint source TSS load, tons/year	**Total point source TSS load, tons/year**
21,242	191

Table 22. Estimated annual Total Suspended Solids load from nonpoint sources for the Guest River Watershed, tons/year

Watershed Name	Total	Residential	Commercial	Industrial	Trans, com, ut	Railroad	Row crop	Pasture	Forest, scrub, orchard	Active strip mine	Reclaimed strip mine	Abandoned strip mine	Borrow, disturbed	Stream bank	road bank	Unpaved Road	Livestock
Guest River A	948	87	11	0	1	0	0	81	388	0	0	250	77	6	15	31	1
Crab Orchard Br.	570	138	0	0	1	0	0	51	180	0	3	45	116	6	16	13	0
Guest River B	633	157	16	0	3	0	1	68	343	0	0	6	16	4	5	14	0
Pine Camp Cr.	331	56	1	0	0	0	0	58	191	0	0	0	0	7	7	10	0
Guest River C	82	35	5	0	0	0	0	10	29	0	0	0	0	0	3	1	0
lower Toms Creek	120	61	14	0	12	0	0	5	22	0	0	4	0	0	1	1	0
Little Toms Cr.	1240	219	33	1	50	0	0	42	306	0	0	511	0	23	26	27	1
upper Toms Creek	2108	272	68	7	2	0	0	185	459	4	14	882	72	36	69	37	2
Guest River D	1707	250	84	42	25	0	2	161	447	0	0	291	308	28	34	32	1
Burns Cr.	282	15	0	0	1	0	0	5	241	0	0	1	0	0	9	9	0
Guest River E	634	31	13	19	18	4	0	29	398	1	0	35	0	19	42	24	0
Guest River F	159	8	26	3	4	0	0	0	6	0	101	8	0	0	2	1	0
lower Bear Cr.	451	31	1	44	10	0	0	10	79	0	1	232	0	24	12	7	0
Yellow Cr.	1396	518	199	38	0	0	0	121	119	0	57	307	8	10	9	10	0
upper Bear Cr.	2070	322	102	47	5	0	0	182	256	2	373	648	28	49	35	21	1
Clear Cr.	465	23	0	0	1	0	0	0	405	0	0	0	0	0	8	27	0
Guest River G	2047	347	276	251	62	21	4	27	302	1	104	479	112	25	19	17	0
Sepulcher Cr.	2893	199	21	107	18	0	0	61	375	1322	242	426	12	30	43	36	1
Guest River H	1341	208	3	7	6	0	0	56	260	0	296	405	37	28	15	20	0
Guest River I	1763	1	0	0	2	0	0	34	189	11	908	476	15	34	69	24	0
Total	21242	2978	874	565	223	28	7	1184	4994	1341	2098	5008	801	331	440	362	8

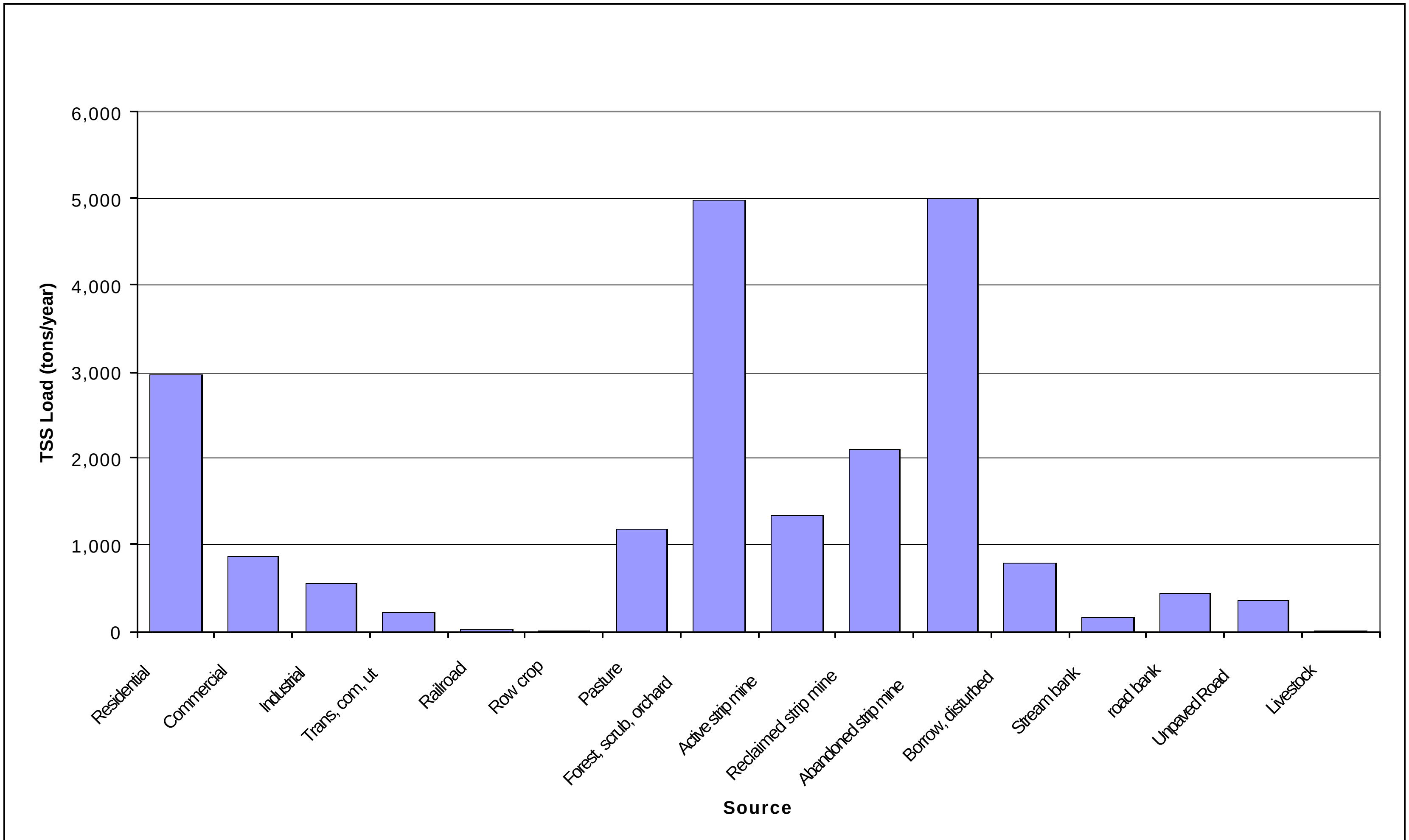


Figure 8. Estimated Total Suspended Solids load from nonpoint sources by source for the Guest River Watershed

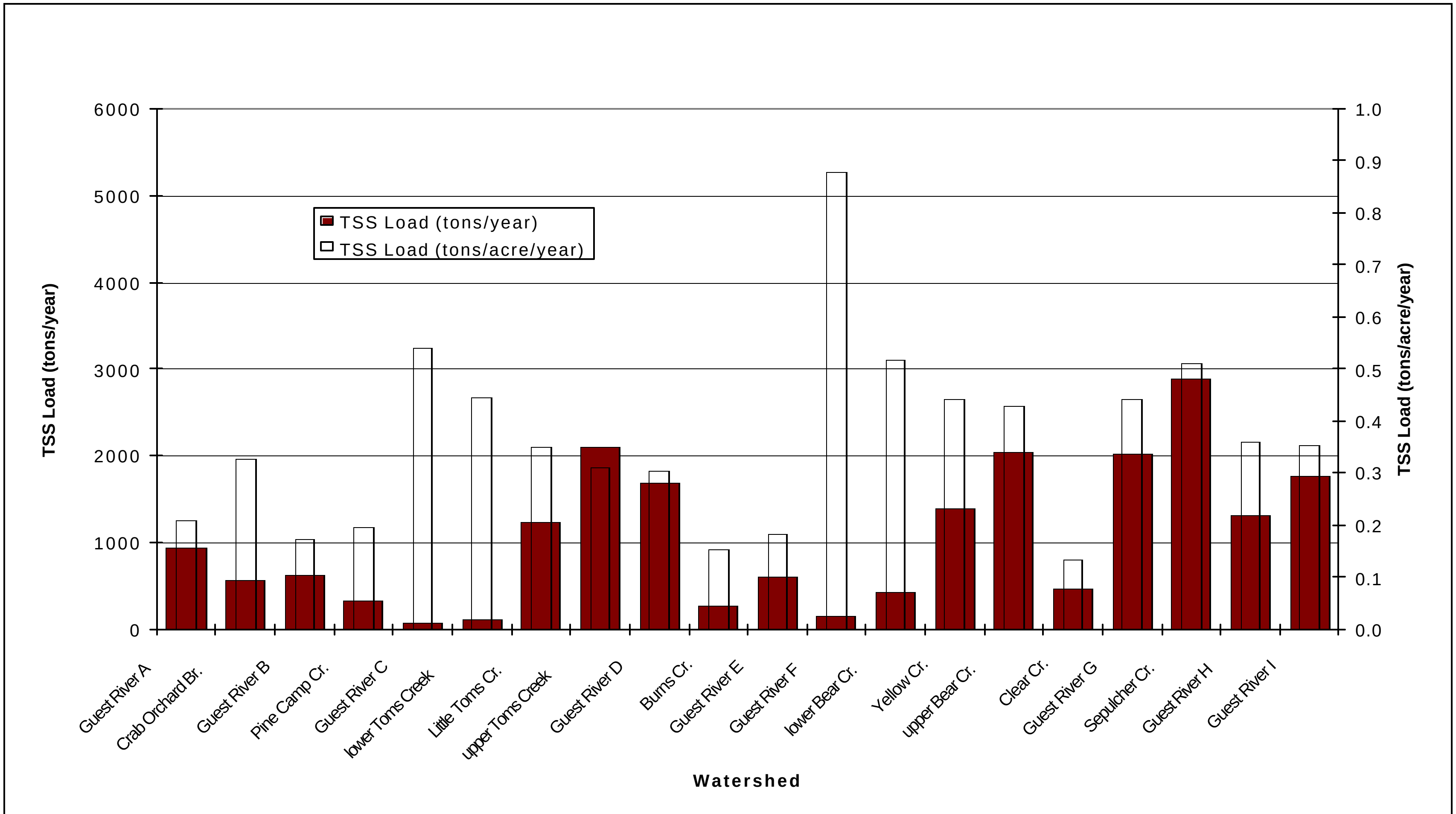


Figure 9. Estimated Total Suspended Solids loads from nonpoint sources, total load by subwatershed and load per acre by subwatershed for the Guest River Watershed

Table 23. Permitted Mining NPDES Points in the Guest River that are actively discharging. (Based on DMLR system report dated 08-02-02)

Company/NPDES	Outfall	MPID
Rocky Coal Co./0081321	001	2670121
Wise Dock Co. Inc./0080324	006	2685563
CBS Land Co./0081169	001	2570016
Cavalier Mining Corp./0080448	002	2683643
Lone Wolf Coal Co. Inc./0081591	A	0002465
ME Coal Co./0080695	001	2781533
Natural Fuel Co./0080269	002	2680521
Paramont Coal Corp./0080781	001	2685165
Paramont Coal Corp./008781	002	2685166
Paramont Coal Corp./0080782	006	2685179
Paramont Coal Corp./0080782	010	2685182
Paramont Coal Corp./0080782	015	2685187
Paramont Coal Corp./0080849	001	2685210
Red River Coal Co./0080044	004	2680197
Red River Coal Co./0080084	005	0001343
Red River Coal Co./0080084	010	2680295
Red River Coal Co./0080514	S-2	2680934
Red River Coal Co./0080514	S-4	2680937
Red River Coal Co./0080624	009	0001597
Red River Coal Co./0080624	010	0001598
Red River Coal Co./0080624	001	2686049
Red River Coal Co./0080624	005	2686053
Red River Coal Co./0080624	006	2686054

Company/NPDES	Outfall	MPID
Red River Coal Co./0080632	4	2685924
Red River Coal Co./0080711	006	2685850
Rocky Coal Co./0081321	001	2670121
Tacoma Fuel Co. Inc./0080954	002	2585324

Table 24. Point-source loads of Total Suspended Solids, Total Phosphorus, and Total Nitrogen for the Guest River Watershed

				Estimated loads, tons/year		
Permit No	**Permitted Discharge, Million gallons per day**	**Facility Name**	**Receiving Stream**	**TSS**	**TP**	**TN**
VA0023477	0.03	VDOC/Wise Correctional Unit # 18 STP	U.T. to Bad Branch of Guest River	1.4	0.091	0.27
VA0030112	0.058	Wise Town of/ Water Treatment Plant	Bear Creek, UT	2.1	0	0
VA0031496	0.003	Paramont Land Company STP	Bear Creek	0.14	0.0091	0.027
VA0052388	0.045	Toms Creek Water Treatment Plant	Toms Creek	1.4	0	0
VA0062375	0.007	Lee Norse STP	Bear Creek	0.32	0.021	0.064
VA0077828	4	Coeburn Norton Wise Regional WWTP	Guest River	182	12	36
VAG400020	0.001	Residence	Bear Creek	0.046	0.0030	0.0091
VAG400060	0.001	Residence	Bear Creek, UT	0.046	0.0030	0.0091
VAG400218	0.001	Residence	Bear Creek, UT	0.046	0.0030	0.0091
VAG400234	0.001	Residence	Bear Creek, UT	0.046	0.0030	0.0091
VAG400266	0.001	Residence	Guest River	0.046	0.0030	0.0091
VAG400265	0.001	Residence	Guest River	0.046	0.0030	0.0091
VAG400292	0.001	Residence	Guest River, UT	0.046	0.0030	0.0091
VAG400322	0.001	Residence	Guest River, UT	0.046	0.0030	0.0091
VAG400320	0.001	Residence	Guest River, UT	0.046	0.0030	0.0091
VAG400293	0.001	Residence	Guest River, UT	0.046	0.0030	0.0091
VAG400110	0.001	Residence	Guest River, UT	0.046	0.0030	0.0091
VAG400305	0.001	Residence	Little Tom's Creek	0.046	0.0030	0.0091
VAG400357	0.001	Residence	Little Toms Creek, UT	0.046	0.0030	0.0091
VAG400362	0.001	Residence	Little Tom's Creek. UT	0.046	0.0030	0.0091
VAG400318	0.001	Residence	Parson's Branch,UT	0.046	0.0030	0.0091
VAG400369	0.001	Residence	Pine Branch	0.046	0.0030	0.0091
VAG400252	0.001	Residence	Pole Bridge Branch, UT	0.046	0.0030	0.0091
VAG400267	0.001	Residence	Sepulcher Creek	0.046	0.0030	0.0091

				Estimated loads, tons/year		
Permit No	**Permitted Discharge, Million gallons per day**	**Facility Name**	**Receiving Stream**	**TSS**	**TP**	**TN**
VAG400289	0.001	Residence	Sepulcher Creek	0.046	0.0030	0.0091
VAG400348	0.001	Residence	Sepulcher Creek, UT	0.046	0.0030	0.0091
VAG400255	0.001	Flatwoods Freewill Baptist Church	Shade Branch, UT	0.046	0.0030	0.0091
VAG400300	0.001	Residence	Tom's Creek	0.046	0.0030	0.0091
VAG400246	0.001	D & J Feed Incorporated	Tom's Creek	0.046	0.0030	0.0091
VAG400197	0.001	Virginia Iron Coal & Coke Company/Toms Creek STP	Tom's Creek	0.046	0.0030	0.0091
VAG400247	0.001	John Ring Trucking Incorporated STP	Tom's Creek	0.046	0.0030	0.0091
VAG400393	0.001	Residence	Toms Creek, UT	0.046	0.0030	0.0091
VAG400294	0.001	Residence	Tom's Creek, UT	0.046	0.0030	0.0091
VAG400390	0.001	Residence	Tom's Creek, UT	0.046	0.0030	0.0091
VAG400229	0.001	Residence	Yellow Creek	0.046	0.0030	0.0091
VAG400394	0.001	Residence	Yellow Creek	0.046	0.0030	0.0091
VAG400091	0.001	Residence	Yellow Creek	0.046	0.0030	0.0091
VAG400224	0.001	Residence	Yellow Creek	0.046	0.0030	0.0091
VAG400019	0.001	Bethel Chapel Church STP	Yellow Creek	0.046	0.0030	0.0091
VAG400260	0.001	Residence	Yellow Creek, UT	0.046	0.0030	0.0091
VAG400052	0.001	Residence	Yellow Creek, UT	0.046	0.0030	0.0091
		Total		**191**	**12**	**37**

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Appendix A. Estimated Nutrient Loads

Estimated Nonpoint Source Total Nitrogen Load

The estimated annual total nitrogen (TN) load from selected nonpoint sources to each watershed within the Guest River Watershed is shown in Table 25. The estimated annual TN load from the Guest River Watershed is about 116 tons per year. The contribution of TN for the Guest River Watershed is shown in Figure 10 Figure 11. Previously mined areas contribute 31% of the total, active mines contribute 5.8%, urban sources account for about 23%, forest contributes 22%, and agriculture generates about 10%.

Figure 11 shows the TN load from each watershed within the Guest River Watershed. The load is distributed relatively evenly among subwatersheds, but upper Toms Creek, Guest River G, and Bear Creek subwatershed each contribute over 10% of the total load. The Guest River F subwatershed generates conspicuously high loading rates on an area basis.

Estimated Point Source Total Nitrogen Load

As with sediment, TN generated by mine sites was included in the nonpoint source calculations. TN loads for other permitted discharges were calculated using a TN concentration of 6 mg/l, except for water-supply plants, for which a TN concentration of zero is assumed. The sum of these point-source TN loads is 37 tons per year, 32% of the estimated nonpoint source loads (Table 24).

Table 25. Estimated annual Total Nitrogen load from nonpoint sources for the Guest River Watershed, tons/year

Watershed Name	Total	Residential	Commercial	Industrial	Trans, com, ut	Railroad	Row crop	Pasture	Forest, scrub, orchard	Active strip mine	Reclaimed strip mine	Abandoned strip mine	Borrow, disturbed	Stream bank	road bank	Unpaved Road	Livestock
Guest River A	5.25	0.39	0.10	0.00	0.01	0.00	0.00	0.81	1.94	0.00	0.00	1.25	0.38	0.03	0.07	0.15	0.09
Crab Orchard Br.	3.05	0.62	0.00	0.00	0.01	0.00	0.00	0.51	0.90	0.00	0.01	0.23	0.58	0.00	0.08	0.06	0.04
Guest River B	3.54	0.71	0.15	0.00	0.05	0.00	0.01	0.68	1.73	0.00	0.00	0.03	0.08	0.01	0.03	0.07	0.00
Pine Camp Cr.	1.93	0.25	0.01	0.00	0.01	0.00	0.00	0.58	0.96	0.00	0.00	0.00	0.00	0.03	0.04	0.05	0.00
Guest River C	0.46	0.16	0.04	0.00	0.00	0.00	0.00	0.10	0.14	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
lower Toms Creek	0.81	0.27	0.12	0.00	0.22	0.00	0.00	0.05	0.11	0.00	0.00	0.02	0.00	0.00	0.01	0.01	0.00
Little Toms Cr.	7.12	0.98	0.33	0.00	0.90	0.00	0.00	0.42	1.53	0.00	0.00	2.56	0.00	0.07	0.13	0.13	0.06
upper Toms Creek	11.80	1.22	0.69	0.02	0.03	0.00	0.00	1.85	2.29	0.02	0.07	4.41	0.36	0.14	0.35	0.18	0.17
Guest River D	9.79	1.13	0.75	0.13	0.46	0.00	0.02	1.61	2.23	0.00	0.00	1.46	1.54	0.02	0.17	0.16	0.11
Burns Cr.	1.45	0.07	0.00	0.00	0.02	0.00	0.00	0.05	1.21	0.00	0.00	0.00	0.00	0.00	0.04	0.05	0.00
Guest River E	3.47	0.14	0.14	0.06	0.32	0.01	0.00	0.29	1.99	0.01	0.00	0.18	0.00	0.00	0.21	0.12	0.00
Guest River F	0.94	0.04	0.24	0.01	0.07	0.00	0.00	0.00	0.03	0.00	0.50	0.04	0.00	0.00	0.01	0.00	0.00
lower Bear Cr.	2.25	0.14	0.01	0.13	0.18	0.00	0.00	0.10	0.39	0.00	0.00	1.16	0.00	0.00	0.06	0.04	0.04
Yellow Cr.	8.15	2.33	1.86	0.11	0.01	0.00	0.00	1.21	0.60	0.00	0.28	1.53	0.04	0.04	0.04	0.05	0.04
upper Bear Cr.	11.47	1.45	0.97	0.14	0.10	0.00	0.00	1.82	1.28	0.01	1.86	3.24	0.14	0.10	0.17	0.11	0.08
Clear Cr.	2.33	0.10	0.00	0.00	0.02	0.00	0.00	0.00	2.03	0.00	0.00	0.00	0.00	0.00	0.04	0.14	0.00
Guest River G	11.54	1.56	2.49	0.75	1.12	0.06	0.04	0.27	1.51	0.00	0.52	2.39	0.56	0.03	0.10	0.09	0.04
Sepulcher Cr.	14.79	0.90	0.19	0.32	0.33	0.00	0.00	0.61	1.88	6.61	1.21	2.13	0.06	0.10	0.22	0.18	0.06
Guest River H	6.92	0.94	0.03	0.02	0.12	0.00	0.00	0.56	1.30	0.00	1.48	2.02	0.19	0.06	0.08	0.10	0.04
Guest River I	9.01	0.01	0.00	0.00	0.04	0.00	0.00	0.34	0.94	0.05	4.54	2.38	0.08	0.17	0.34	0.12	0.00
Total	116.05	13.40	8.15	1.69	4.01	0.09	0.07	11.84	24.99	6.70	10.49	25.04	4.01	0.79	2.20	1.81	0.75

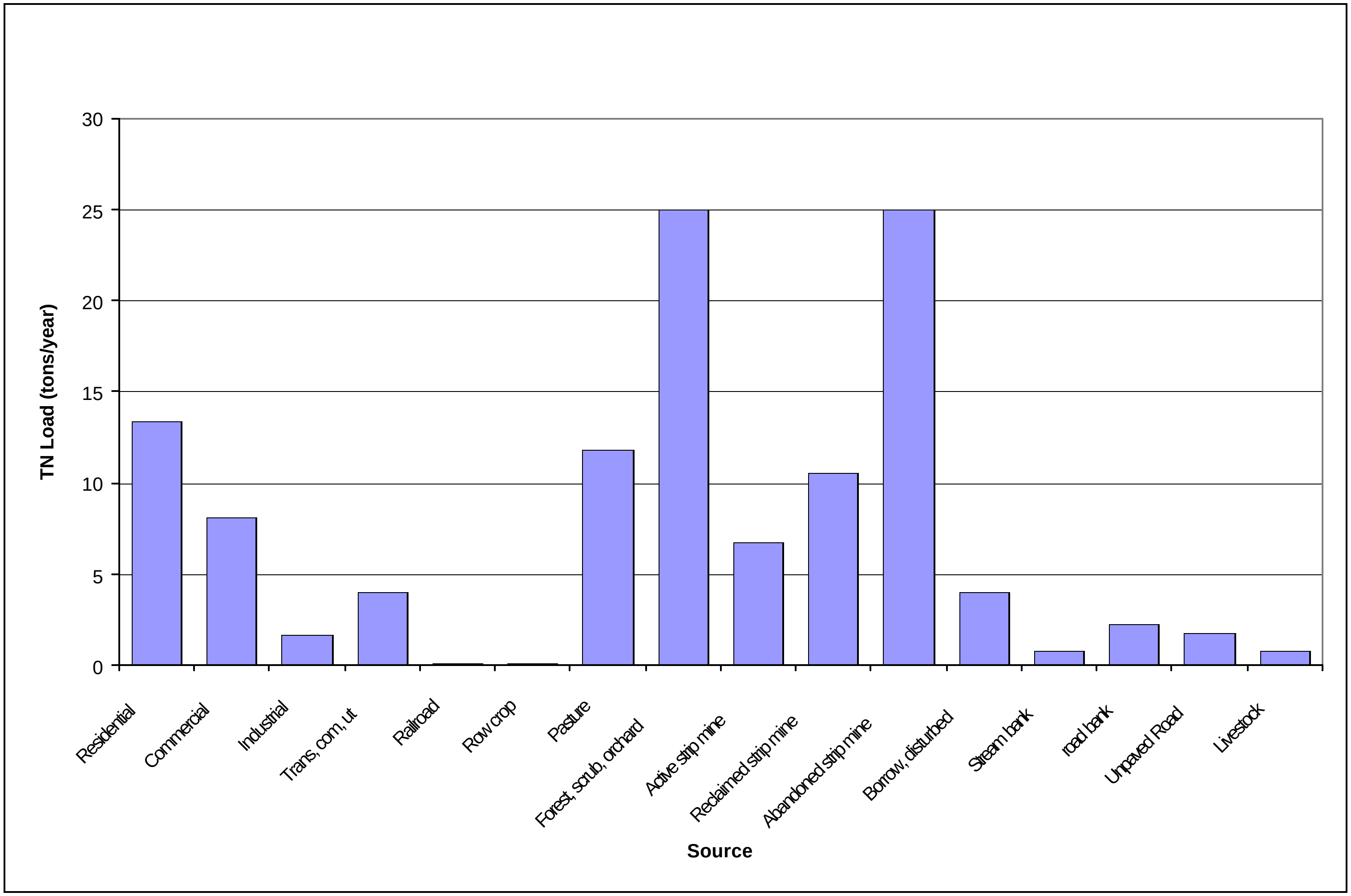


Figure 10. Estimated Total Nitrogen loading from nonpoint sources by source for the Guest River Watershed

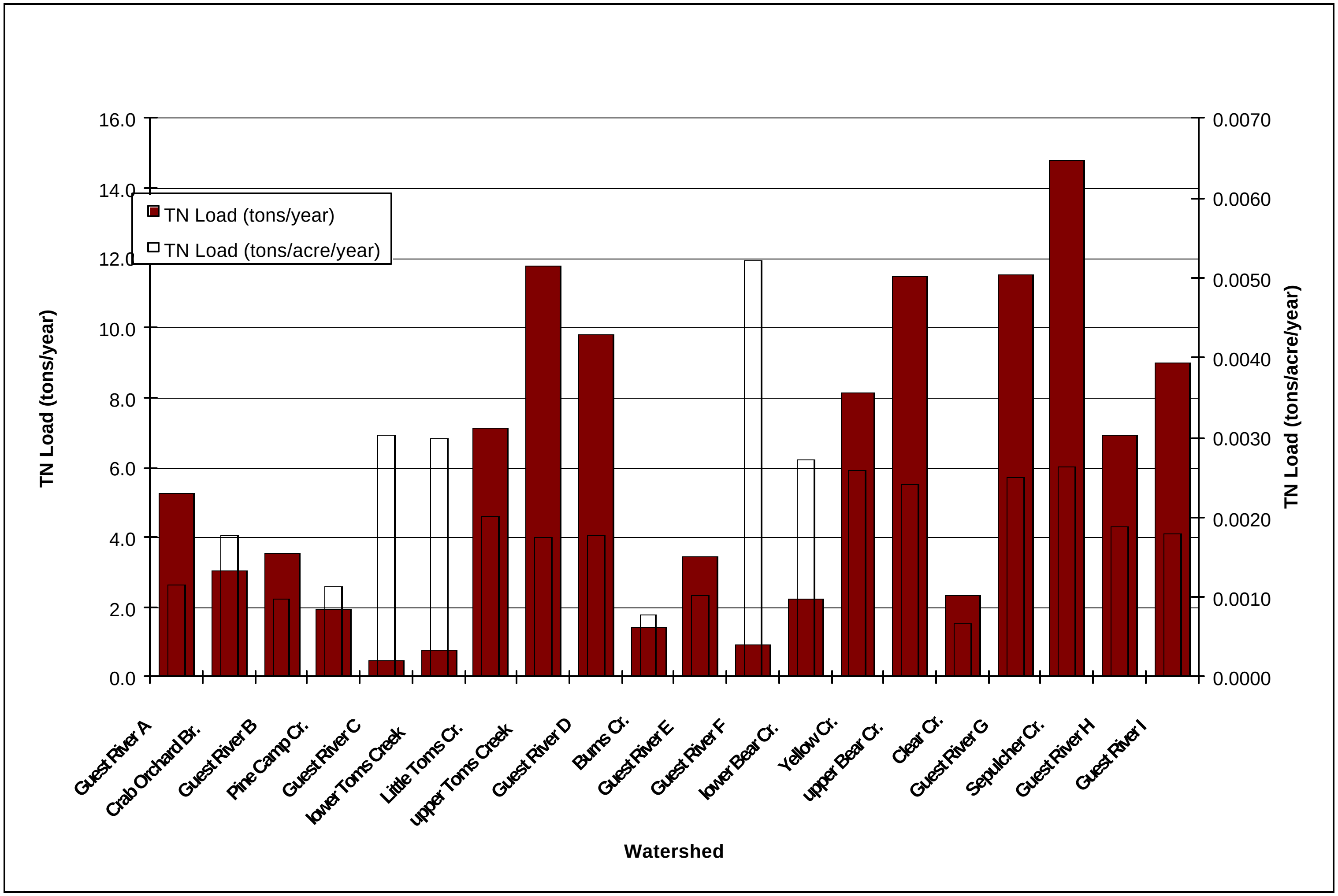


Figure 11. Estimated annual Total Nitrogen load from nonpoint sources, total load by subwatershed and load/acre by subwatershed, for the Guest River Watershed

Estimated Nonpoint Source Total Phosphorus Load

The estimated annual total phosphorus (TP) load from selected nonpoint sources to each watershed within the Guest River Watershed is shown in Table 26. The estimated annual TP load from the Guest River Watershed is 30.5 tons per year. The contribution of TP by source for the Guest River Watershed is shown in Figure 12. Residential areas account for 48% of the TP load, and other urban land uses account for another 23%. Previously mined land contributes 12% and forest land contributes 8% of the total TP load.

Figure 13 shows the TP load from each watershed within the Guest River Watershed. Only Yellow Creek, and upper Bear Creek subwatersheds each contribute over 10% of the total load. Lower Toms Creek, Guest River C and Guest River F subwatersheds generates high rates of loading on an area basis.

Estimated Point Source Total Phosphorus Load

As in TSS and TN, the TP contribution from mining discharges is accounted for in the nonpoint source calculations. TP loads for other permitted discharges were calculated using a TP concentration of 2 mg/l, except for water-supply plants, for which a TP concentration of zero is assumed. The sum of these point-source TP loads is 12 tons per year, 39% of the estimated nonpoint source TP loads (Table 24).

Table 26. Total Phosphorus loading from nonpoint sources for the Guest River Watershed, tons/year

Subwatershed Name	Total	Residential	Commercial	Industrial	Trans, com, ut	Railroad	Row crop	Pasture	Forest, scrub, orchard	Active strip mine	Reclaimed strip mine	Abandoned strip mine	Borrow, disturbed	Stream bank	road bank	Unpaved Road	Livestock
Guest River A	0.9	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Crab Orchard Br.	0.9	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
Guest River B	1.1	0.8	0.1	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pine Camp Cr.	0.4	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Guest River C	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
lower Toms Creek	0.4	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Little Toms Cr.	2.0	1.1	0.2	0.0	0.2	0.0	0.0	0.0	0.2	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0
upper Toms Creek	2.7	1.4	0.4	0.0	0.0	0.0	0.0	0.1	0.2	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.1
Guest River D	2.6	1.3	0.4	0.1	0.1	0.0	0.0	0.1	0.2	0.0	0.0	0.1	0.2	0.0	0.0	0.0	0.0
Burns Cr.	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Guest River E	0.6	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Guest River F	0.3	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
lower Bear Cr.	0.5	0.2	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Yellow Cr.	4.1	2.6	1.0	0.1	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0
upper Bear Cr.	3.1	1.6	0.5	0.2	0.0	0.0	0.0	0.1	0.1	0.0	0.2	0.3	0.0	0.0	0.0	0.0	0.0
Clear Cr.	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Guest River G	4.8	1.7	1.4	0.8	0.2	0.0	0.0	0.0	0.2	0.0	0.1	0.2	0.1	0.0	0.0	0.0	0.0
Sepulcher Cr.	2.8	1.0	0.1	0.4	0.1	0.0	0.0	0.0	0.2	0.7	0.1	0.2	0.0	0.0	0.0	0.0	0.0
Guest River H	1.6	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.2	0.0	0.0	0.0	0.0	0.0
Guest River I	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.5	0.2	0.0	0.0	0.0	0.0	0.0
Total	30.5	14.9	4.5	1.9	0.8	0.0	0.0	0.6	2.5	0.7	1.0	2.5	0.4	0.1	0.2	0.2	0.3

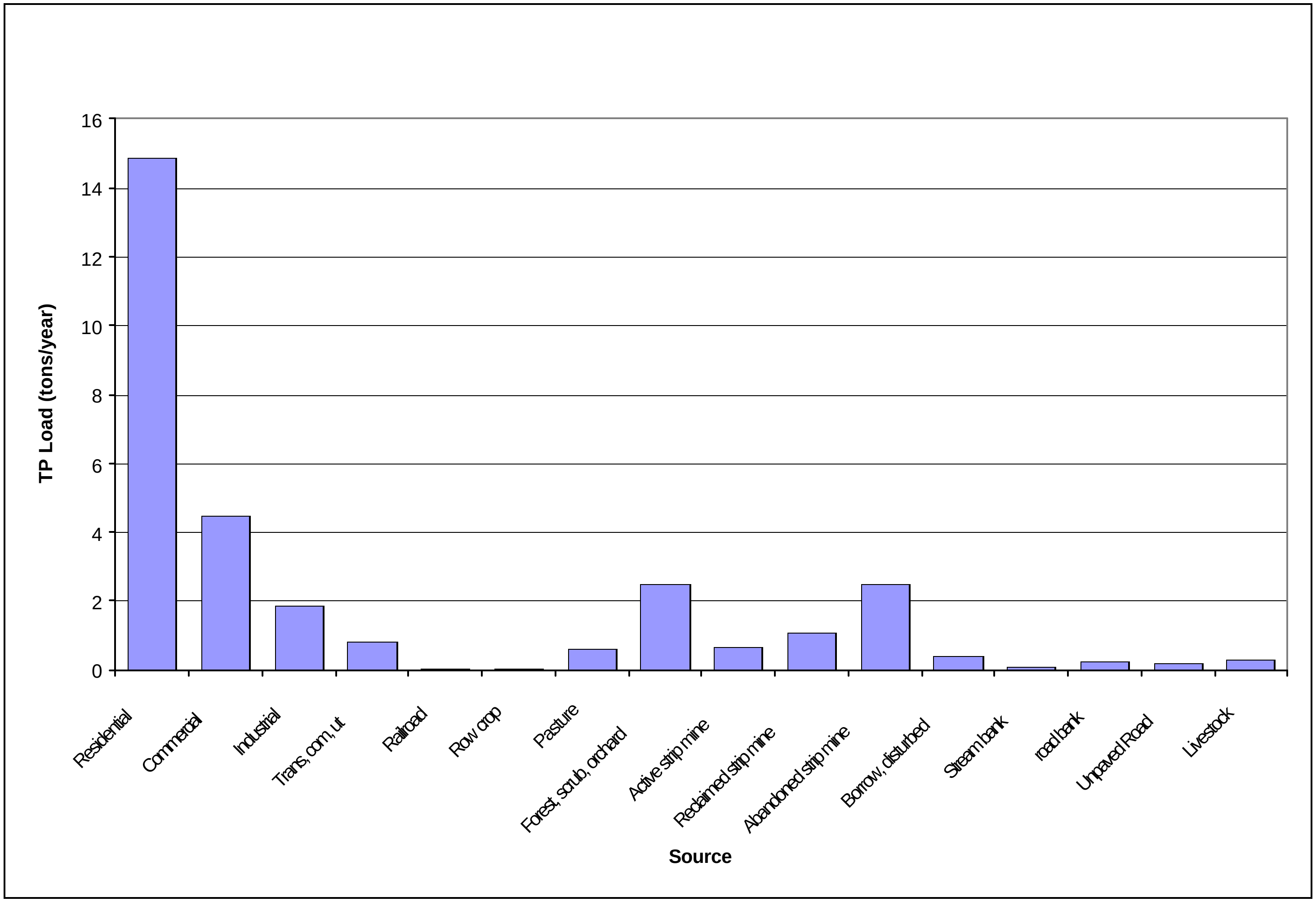


Figure 12. Estimated annual Total Phosphorus load from nonpoint sources by source for the Guest River Watershed

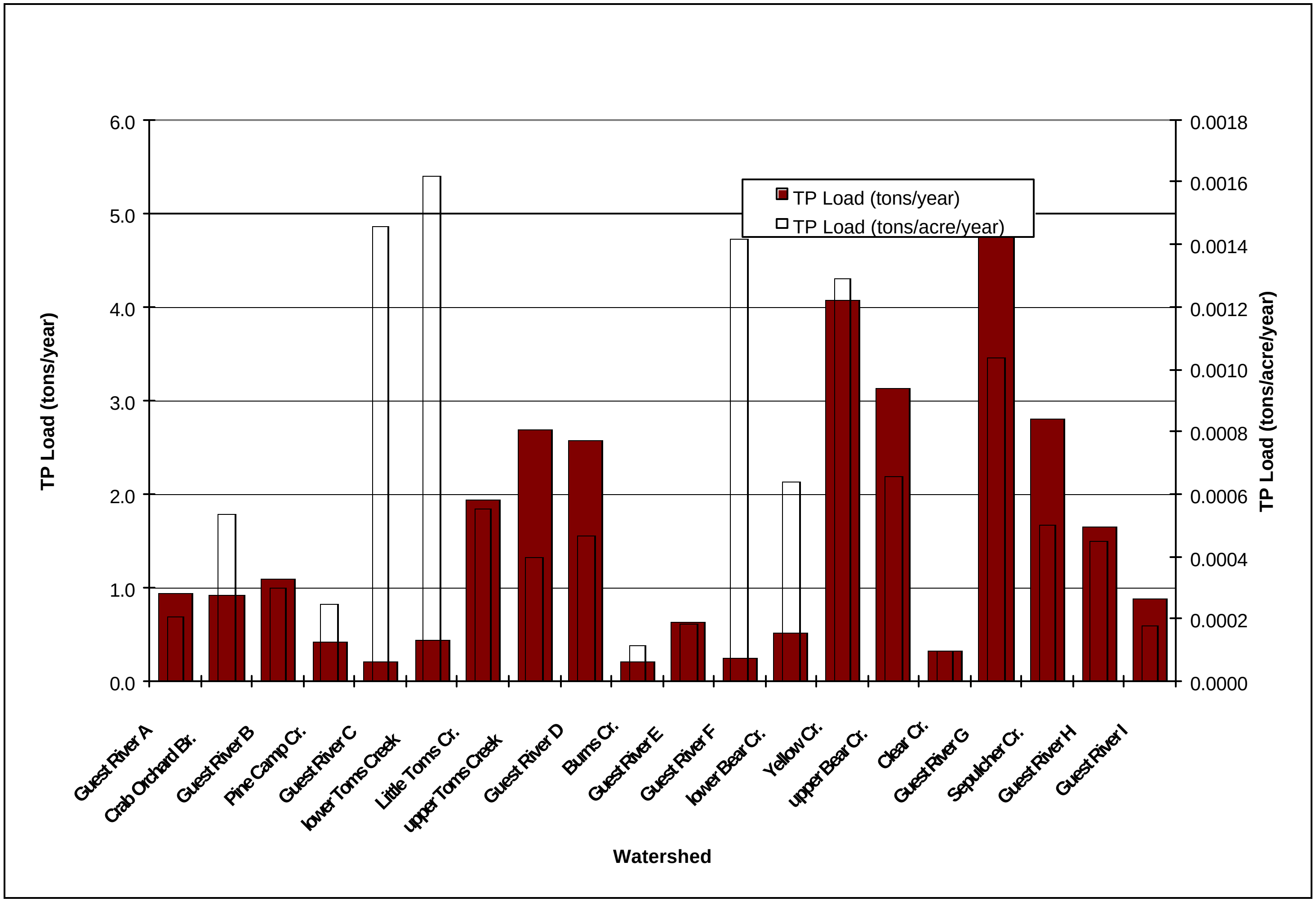


Figure 13. Estimated annual Total Phosphorus load from nonpoint sources, total load and load per acre, by subwatershed for the Guest River Watershed

Appendix B. Comparison between Modeled Loads and Water Quality Monitoring

TVA has monitored water quality at several locations in the Guest River Watershed since 1996. The data resulting from this monitoring can provide a basis for judging the ability of the loading model to account for the processes that generate pollution. Data were available for 13 sites for TSS, 10 sites for TN and 9 sites for TP.

Because the number of samples at these sites were limited and therefore did not necessarily represent the full range of conditions, and because of the bias inherent in the single-stage sediment sampler used for TSS sampling, the absolute magnitude of loading estimates calculated from them are not reliable.

Therefore, instead of calculating loading, a surrogate was used. Median concentrations at the stations were assumed to represent the relative loading contributions at each sampling site. Since many models use watershed area as the main independent variable in calculating watershed discharge, watershed areas were used as a substitute for relative stream flow rates at the stations. The product of these two factors (median concentration times watershed area) should be proportional to the pollutant load passing the sampling site. This load surrogate was compared against modeled loads by regression analysis.

TSS is the most important parameter for this study. The model agreement with measured values was very good (R^2 = 0.84, Figure 14). However, the model appears to underestimate the relative amount of TSS generated in the subwatersheds that are mostly forested. In addition, the model estimate was initially particularly low the Sepulcher Creek subwatershed. When it was observed that tipples outside of the confines of regulated surface mines operated in the Sepulcher Creek subwatershed, the P value (representing practices that prevent sediment from leaving a site) was adjusted upward for tipples in this subwatershed only. The P value was selected for the best fit of this point to the modeled TSS vs. measured load substitute line.

The TN fit was not as good as the TSS fit (Figure 15). This is to be expected, because the model does not take into account the groundwater contribution of nitrogen. As with TSS, the model tends to underestimate the relative TN contribution of forested subwatersheds.

The TP fit was almost as good as the TSS fit (Figure 16). Again, the model appears to underestimate the relative contribution of forested watersheds.

In calibrating the model, the USLE “C” factor was adjusted upward to decrease the underestimation of loads from forested watersheds. In addition, better fit was attained by adjusting urban runoff concentrations and soil pollutant coefficients.

For further validation, modeling results were compared with biological monitoring data. TVA performed biological assessments of several sites in the Guest in 1995. Both fish community assessments (scored using the Index of Biotic Integrity [IBI]), and benthic macroinvertebrate assessments (scored by counting the number of taxa in the insect orders Ephemeroptera [mayflies], Plecoptera [stoneflies], and Trichoptera [caddisflies], referred to as EPT) were performed at all sites. Nine of these sites represented tributary watersheds and were selected for this analysis.

Modeled TSS load per acre shows a strong relationship to EPT scores (R^2 =0.65) if one outlier – Yellow Creek -- is eliminated from the analysis (Figure 17). The Yellow Creek station had the highest EPT score (and the highest IBI score) of this data subset, but this mixed-land-use watershed also had one of the highest TSS loads. TSS in this subwatershed is mostly driven by the relatively high level of urban land uses, and the relatively healthy biological community is unexpected.

The two biological monitoring techniques are correlated (R^2 = 0.53), and the modeled load estimates are correlated (TP vs. TSS R^2 = 0.46), so other correlation results between biological measures and modeling results are similar.

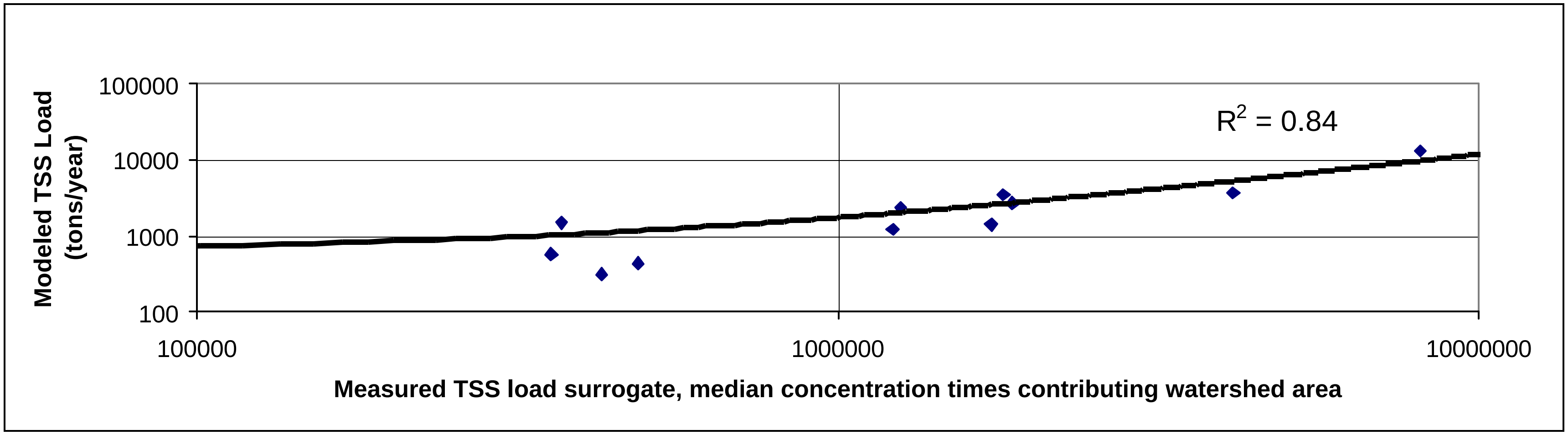


Figure 14. Comparison between monitored and modeled Total Suspended Solids loads in the Guest River Watershed

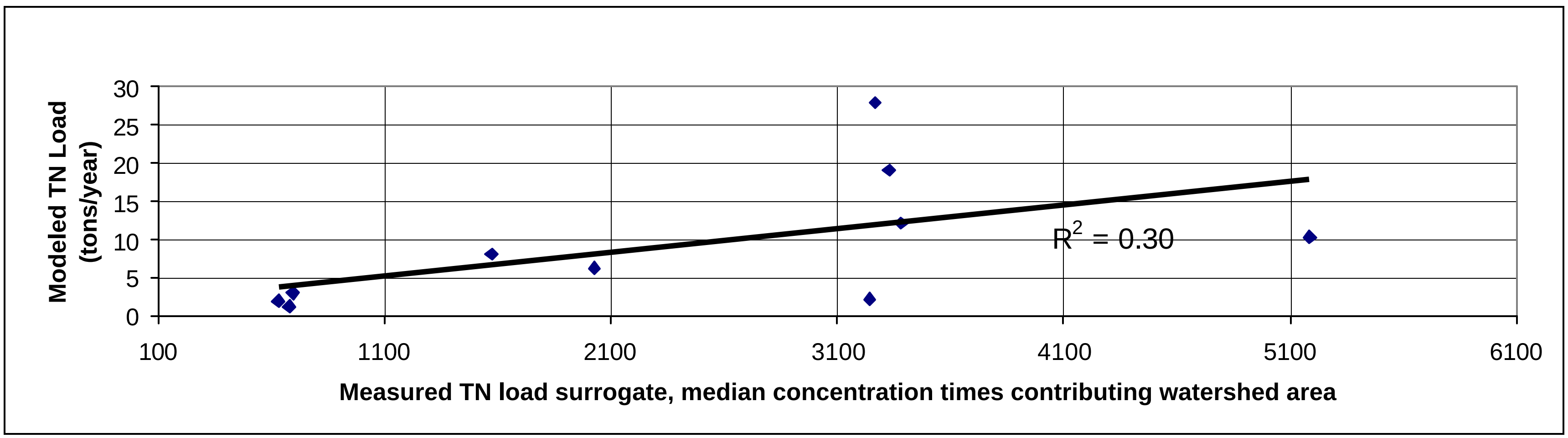


Figure 15. Comparison between monitored and modeled Total Nitrogen loads in the Guest River Watershed

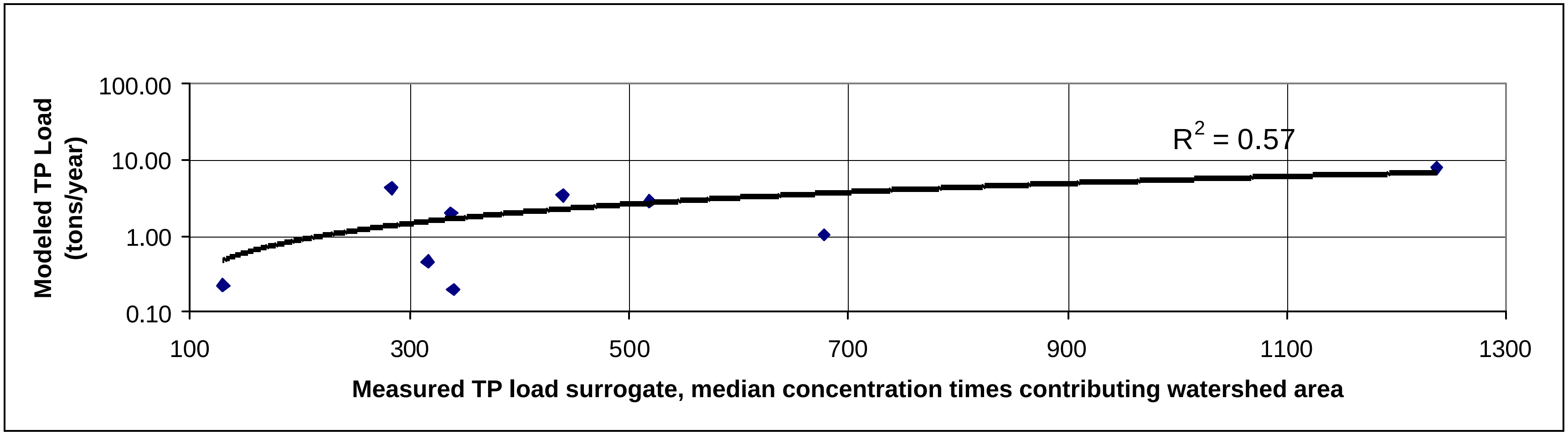


Figure 16. Comparison between modeled and monitored Total Phosphorus loads for the Guest River Watershed

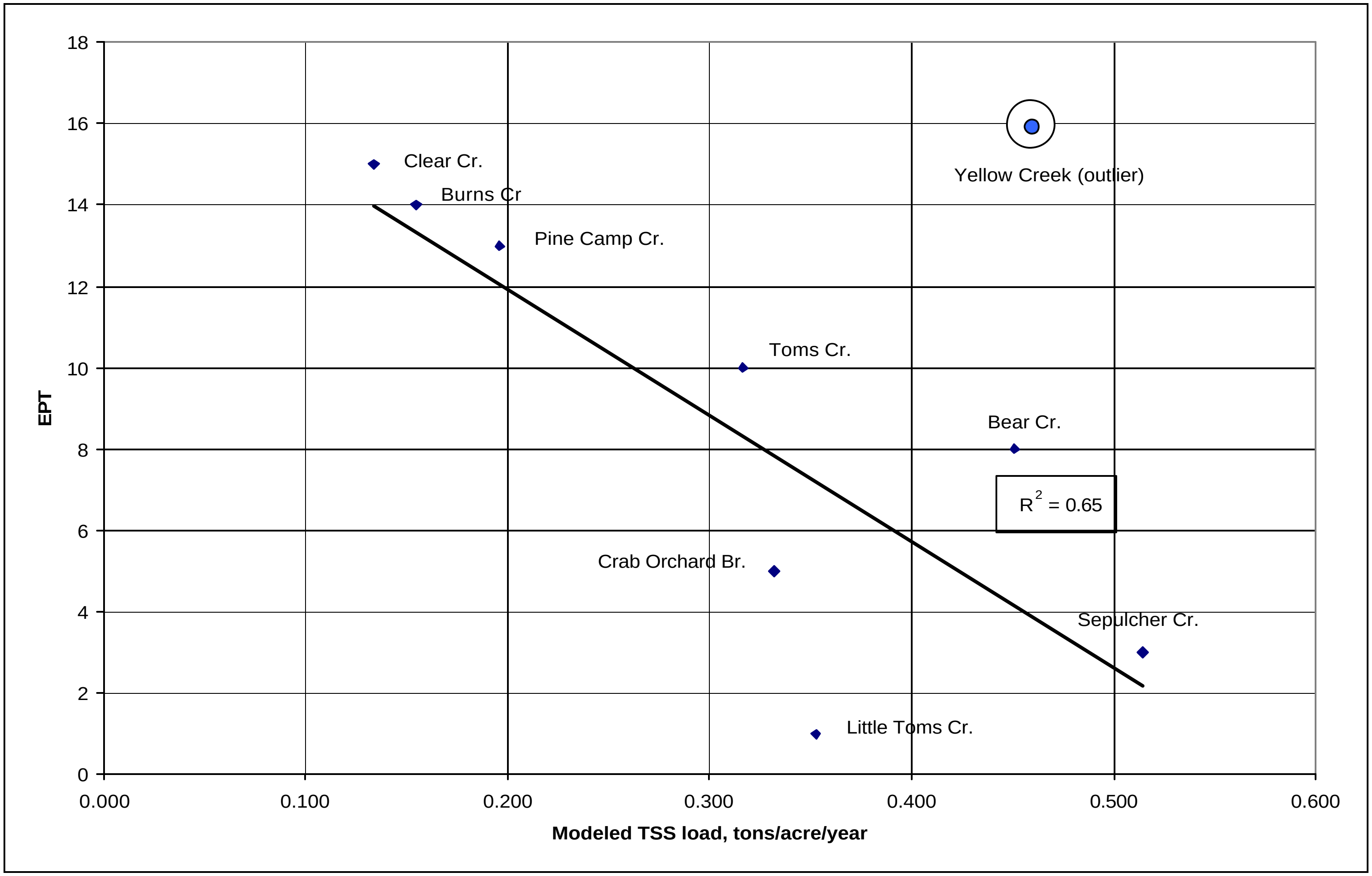


Figure 17. Modeling results compared to biological monitoring data.

Appendix C. Indicator Bacteria Modeling Data

As part of this project, TVA is providing data for further study of bacterial contamination, to be performed by VDEQ. Much of this data is contained in the above section on onsite septic systems. Other pertinent data include livestock and wildlife populations in the watershed, and management practices for handling animal waste and biosolids.

Table 27. Wildlife population factors.

Major Wildlife Species	Population Density (estimated animals per acre- or mile- of occupied habitat)	Population Estimate Multiplier	Watershed Habitat	Direct fecal deposition in streams (%)
Deer	0.0147/acre 0.0600/acre 0.0115/acre	- Total watershed acreage (exclude urban land use acres) - Total National Forest land acreage - Total private land acreage (exclude urban land use acres)	- Entire watershed excluding urban land uses	1
Raccoon	0.0234/acre	- Total watershed acreage	- Entire watershed and prefer areas within 600 ft. of streams and ponds	10
Muskrat	15/mile	- Total miles of perennial streams and pond shoreline	- Within 66 ft of perennial streams and ponds	50
Beaver	1.0/mile 6 per active lodge (most accurate)	- Total miles of occupied streams - Number of occupied bank dens and pond lodges	- Within 300 ft of perennial streams and ponds	90
Mallard duck	0.030/mile	- Total miles of major streams and pond shoreline	- Within 66 ft. of streams and ponds	25
Wood duck	0.027/mile	- Total miles of major streams and pond shoreline	- Within 66 ft of streams and ponds	25
Wild Turkey	0.0043/acre	- Total watershed acreage (exclude urban land use acres)	- Entire watershed excluding urban land uses	1

Source: John Baker, District Wildlife Biologist, Virginia Department of Game and Inland Fisheries, 5/20/02.

Data were gathered for wildlife population density from local authorities (Table 27). This was combined with land use/land cover data to calculate wildlife populations. Livestock data described in previous sections in this report was used to produce estimates of livestock populations (Table 29).

In order to translate wildlife population characteristics into population estimates, some assumptions were necessary. For estimation of deer populations, it was assumed that forest within the Guest River subwatersheds 01; 02, 03; 06, 07, 08, 09; and 10, 11; and the Burns Creek, Pine Camp Creek, and Clear Creek subwatersheds was National Forest Land. For estimating mallard and wood duck populations, it was assumed that 75% of total perennial stream miles in main Guest River subwatersheds were “major” streams, and 25% of total perennial stream miles in tributary subwatersheds were “major”.

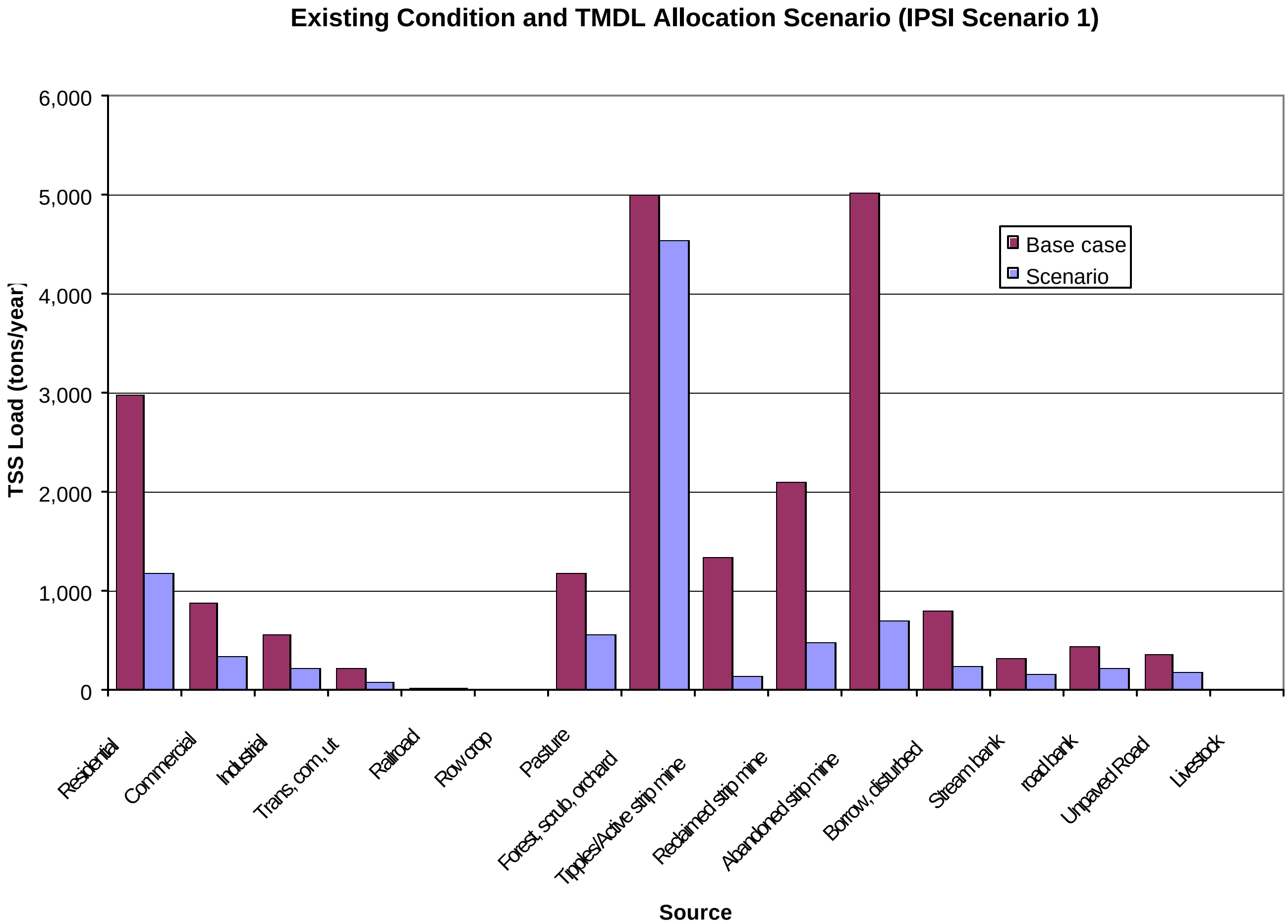
According to the Guest River Technical committee, there is essentially no spreading of livestock waste on agricultural fields, because there is little or no livestock confinement. There is no spreading of biosolids.

Table 28. Portion of time livestock confined and in streams

Month	Portion of time confined	Portion of grazing time in stream	Portion of time confined	Portion of grazing time in stream
	Beef cattle		Horses	
Jan	0	0.010	0	0.010
Feb	0	0.010	0	0.010
Mar	0	0.010	0	0.010
Apr	0	0.021	0	0.010
May	0	0.042	0	0.010
Jun	0	0.063	0	0.010
Jul	0	0.063	0	0.010
Aug	0	0.083	0	0.010
Sep	0	0.042	0	0.010
Oct	0	0.031	0	0.010
Nov	0	0.010	0	0.010
Dec	0	0.010	0	0.010

Table 29. Estimated populations of livestock and wildlife

Subwatershed Name	Subwatershed ID	Total cattle, adjacent	Total cattle, non-adjacent	Total Horses adjacent	Total Horses, non-adjacent	Deer	Raccoon	Muskrat	Beaver	Mallard	Wood duck	Wild Turkey
Guest River A	01	50	40	0	0	61	106	212	14	0.3	0.3	18
Crab Orchard Br.	0201, 0202	20	10	0	1	16	40	46	3	0.0	0.0	6
Guest River B	02, 03	0	20	3	0	46	85	194	13	0.3	0.3	14
Pine Camp Cr.	0401, 0402	0	30	0	1	23	40	75	5	0.0	0.0	7
Guest River C	04, 05	0	0	0	0	1	4	27	2	0.0	0.0	0
lower Toms Creek	0601	0	0	0	0	1	6	17	1	0.0	0.0	0
Little Toms Cr.	060201, 060202	30	20	0	0	32	82	66	4	0.0	0.0	12
upper Toms Creek	0602, 0603, 0604	90	70	1	4	64	158	199	13	0.1	0.1	24
Guest River D	06, 07, 08, 09	60	40	0	2	66	129	241	16	0.4	0.1	20
Burns Cr.	1001, 1002	0	0	0	0	26	43	57	4	0.0	0.0	8
Guest River E	10, 11	0	20	0	0	44	79	223	15	0.3	0.3	13
Guest River F	12	0	0	0	0	1	4	3	0	0.0	0.0	0
lower Bear Cr.	1201, 1202	20	0	0	1	8	19	34	2	0.0	0.0	3
Yellow Cr.	120301, 120302	20	50	0	5	20	74	76	5	0.0	0.0	7
upper Bear Cr.	1203, 1204	40	60	0	2	40	111	158	11	0.1	0.1	15
Clear Cr.	1301, 1302	0	0	0	0	50	81	118	8	0.1	0.1	15
Guest River G	13, 14	20	0	0	0	35	108	131	9	0.2	0.2	13
Sepulcher Cr.	1501, 1502	30	20	0	1	56	132	171	11	0.1	0.1	21
Guest River H	15, 16, 17	20	70	0	1	36	86	94	6	0.1	0.1	14
Guest River I	18	0	20	0	0	45	117	117	8	0.2	0.2	17
Total		400	470	4	18	672	1503	2257	150	2	2	227


Existing Condition and TMDL Allocation Scenario (IPSI Scenario 1)
TSS Load (tons/year)
6,000
5,000
4,000
3,000
2,000
1,000
0
Base case
Scenario
Residential
Commercial
Industrial
Trans, com, ut
Railroad
Row crop
Pasture
Forest, scrub, orchard
Tipples/Active strip mine
Reclaimed strip mine
Abandoned strip mine
Borrow, disturbed
Stream bank
road bank
Unpaved Road
Livestock
Source

Existing Condition and Interim Allocation Scenario (IPSI Scenario 2)